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MARINE CORPS INSTITUTE

FUNDAMENTALS OF DIESEL ENGINES

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WASHINGTON, D.C.

D 214.25:

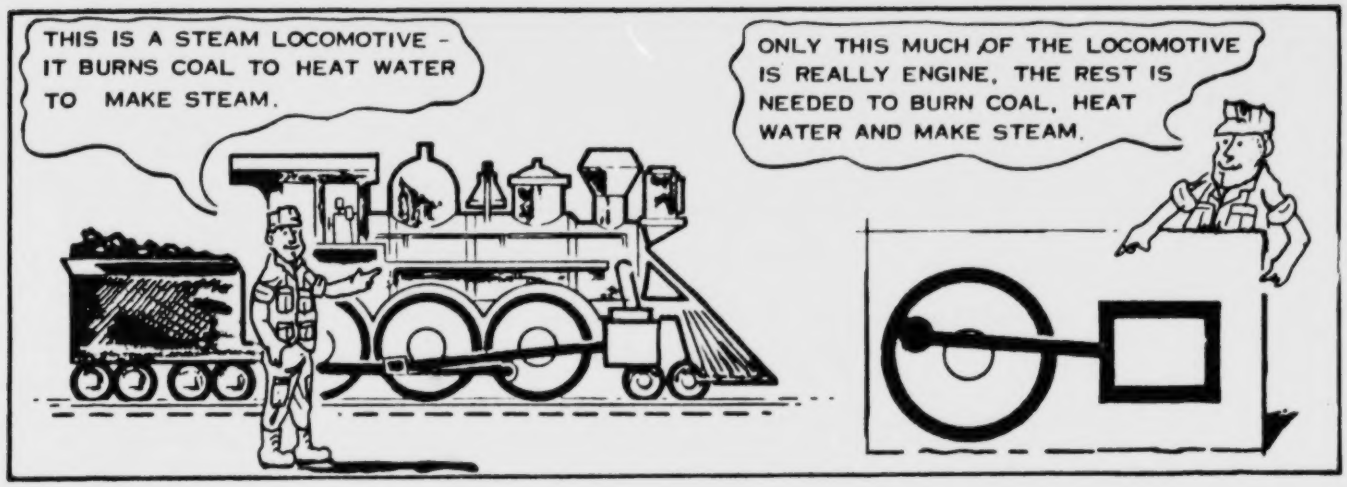
INTRODUCTION

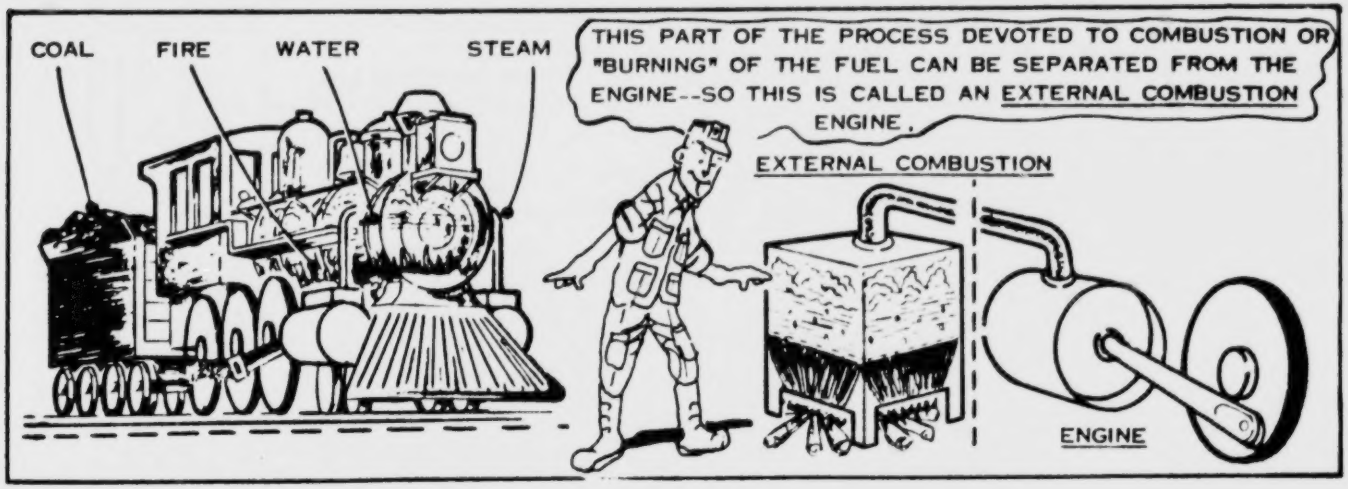
YOU DON'T NEED TO KNOW ANYTHING ABOUT ENGINES BEFORE READING THIS BOOK--HOWEVER, YOU'LL KNOW A GREAT DEAL ABOUT THEM WHEN YOU FINISH!

YOU'LL SPEND SOME TIME ON PRELIMINARIES, BUT THIS WON'T BE WASTED BECAUSE YOU'LL LEARN FUNDAMENTAL PRINCIPLES OF OPERATION AND ACQUIRE A VOCABULARY OF TECHNICAL TERMS.

YOU'LL LEARN ABOUT THE FAMILIAR GASOLINE AUTOMOBILE ENGINE, AND BE TOLD HOW THE DIESEL ENGINE DIFFERS--IN OPERATION AND DESIGN. SIMPLIFIED SKETCHES ILLUSTRATE EVERY IMPORTANT POINT AND PART--FROM A CRANKSHAFT TO A TURBOCHARGER.

BUT LET'S BEGIN AT THE BEGINNING--WITH THE COMBUSTION PROCESS ITSELF. WE'LL ADD A BOILER AND A SIMPLE ENGINE AND MAKE A STEAM LOCOMOTIVE . . . .


THIS IS A STEAM LOCOMOTIVE - IT BURNS COAL TO HEAT WATER TO MAKE STEAM.
ONLY THIS MUCH OF THE LOCOMOTIVE IS REALLY ENGINE, THE REST IS NEEDED TO BURN COAL, HEAT WATER AND MAKE STEAM.


COAL
FIRE
WATER
STEAM
THIS PART OF THE PROCESS DEVOTED TO COMBUSTION OR "BURNING" OF THE FUEL CAN BE SEPARATED FROM THE ENGINE--SO THIS IS CALLED AN EXTERNAL COMBUSTION ENGINE.
EXTERNAL COMBUSTION
ENGINE

COMBUSTION MEANS BURNING – AND AIR IS NEEDED TO MAKE THE COAL BURN.

AIR

WHEN COMBUSTION TAKES PLACE STEAM IS PRODUCED, WHICH RAPIDLY EXPANDS AND CREATES PRESSURE --

THIS PRESSURE IS USED IN THE ENGINE TO MAKE SLIDING PARTS MOVE.

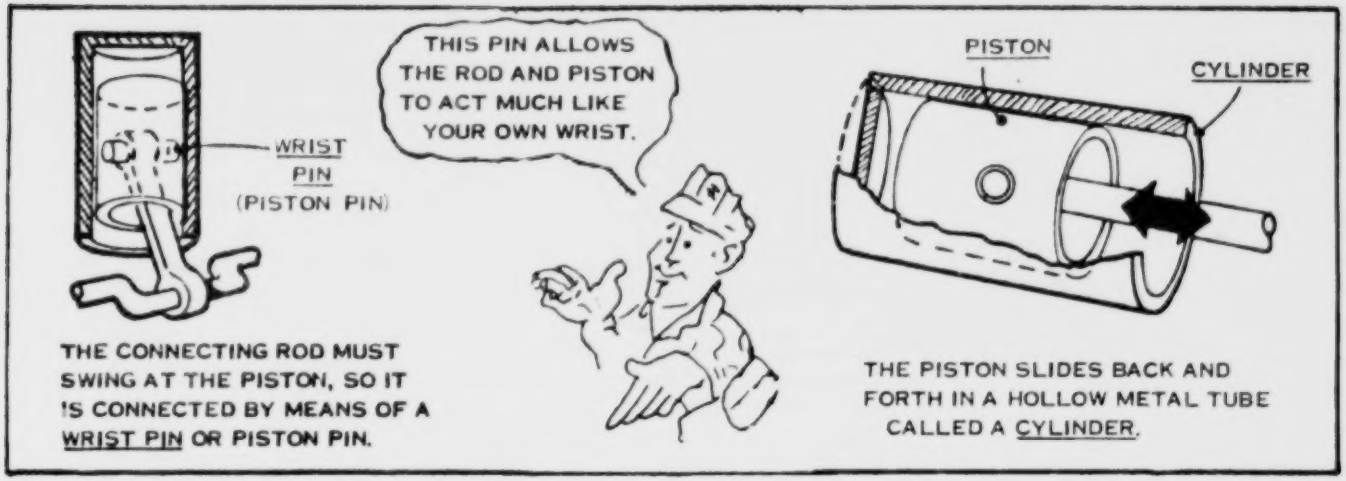
SO PRESSURE OF AN EXPANDING GAS MAKES THE ENGINE OPERATE -

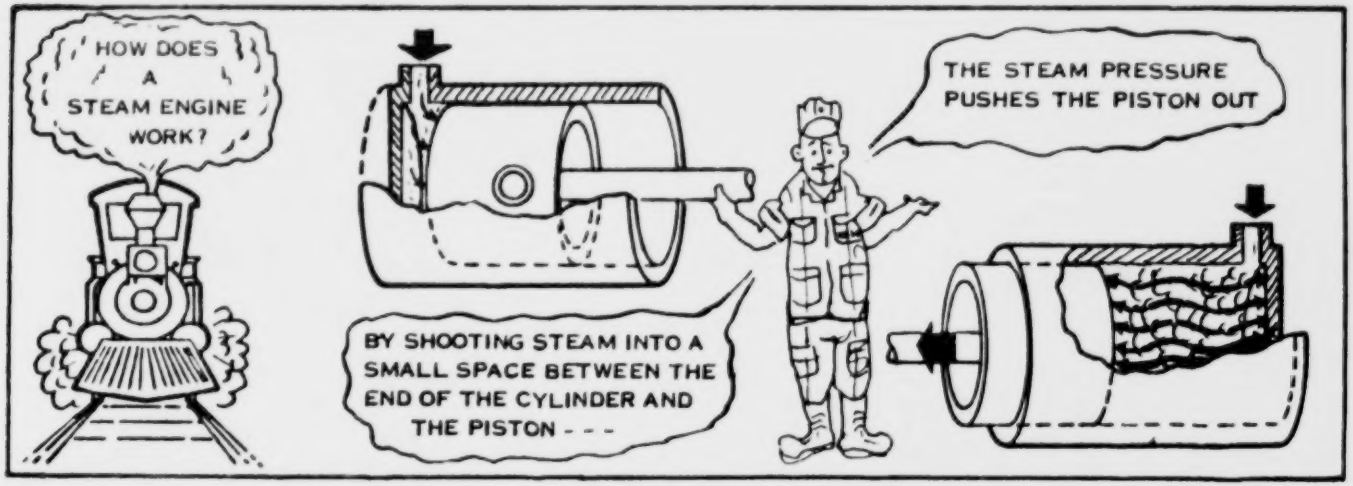
BUT IF YOU LOOK AT THE ENGINE YOU'LL NOTICE IT PRODUCES A BACK AND FORTH MOTION WHILE THE WHEEL GOES ROUND AND ROUND

ENGINE

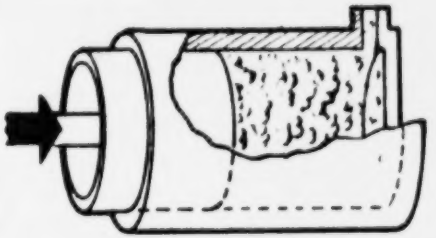
WHEEL

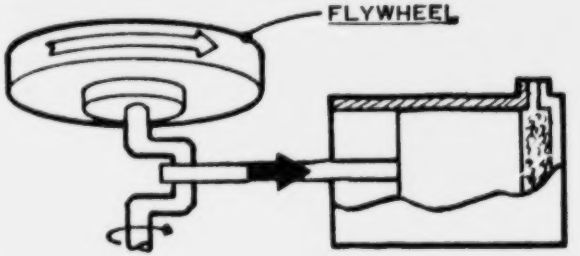
THE SAME THING HAPPENS WHEN YOU RIDE A BICYCLE. YOUR LEGS GO UP AND DOWN WHILE THE PEDALS GO 'ROUND AND 'ROUND.


WRIST PIN
(PISTON PIN)
THIS PIN ALLOWS THE ROD AND PISTON TO ACT MUCH LIKE YOUR OWN WRIST.
PISTON
CYLINDER
THE CONNECTING ROD MUST SWING AT THE PISTON, SO IT IS CONNECTED BY MEANS OF A WRIST PIN OR PISTON PIN.
THE PISTON SLIDES BACK AND FORTH IN A HOLLOW METAL TUBE CALLED A CYLINDER.


HOW DOES A STEAM ENGINE WORK?
THE STEAM PRESSURE PUSHES THE PISTON OUT
BY SHOOTING STEAM INTO A SMALL SPACE BETWEEN THE END OF THE CYLINDER AND THE PISTON - - -

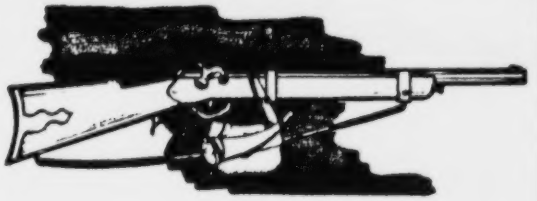
WHEN THE PISTON HAS BEEN PUSHED OUT BY THE STEAM, IT MUST THEN BE PUSHED BACK AGAIN. THIS CAN BE DONE WITH STEAM, BUT - - -





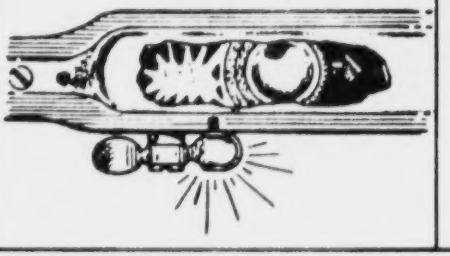
ANOTHER WAY OF DOING IT IS BY LETTING IT "COAST" BACK. WE DO THIS BY ATTACHING A HEAVY WEIGHT OR FLYWHEEL TO THE SHAFT. ONCE THIS FLYWHEEL IS IN MOTION IT WANTS TO KEEP ON TURNING.

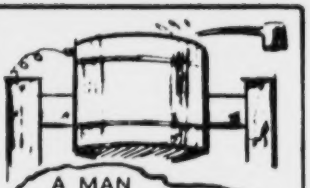
WE COULD HAVE A MUCH SMALLER ENGINE IF WE DIDN'T NEED ALL THIS "EXTERNAL COMBUSTION" APPARATUS. SO LET'S EXAMINE THE PRINCIPLES OF INTERNAL COMBUSTION.



A GUN USES THE PRINCIPLES OF THE INTERNAL COMBUSTION ENGINE. WE DON'T USE EXTERNAL BOILERS TO FIRE THE BULLET; INSTEAD, WE BURN GUNPOWDER.

THE BURNING POWDER FORMS GASES THAT 'SHOOT' THE BULLET OUT OF THE BARREL OF THE GUN.



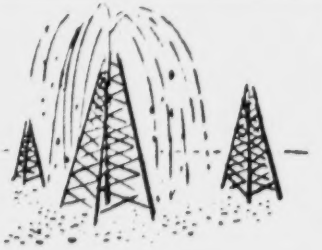


A MAN NAMED HUYGHENS TRIED MAKING AN ENGINE USING GUNPOWDER AS FUEL--

HUYGHENS EXPERIMENTS WITH THE GUN POWDER ENGINE WERE UNSUCCESSFUL.

MANY YEARS LATER RUDOLPH DIESEL TRIED USING COAL DUST FOR FUEL IN AN ENGINE---

AND THIS ENGINE ENDED THE SAME WAY.



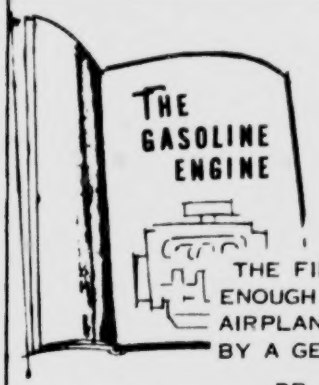
SUBSEQUENT ENGINE EXPERIMENTS USED PETROLEUM PRODUCTS, WHICH CONTAIN EVEN MORE HEAT ENERGY THAN GUNPOWDER, BUT ARE EASIER TO CONTROL.

A. RECIPROCATING
B. CRANK
C. EXTERNAL
D. CYLINDER
E. AIR
F. CRANK
G. COMBUSTION
H. BURN

SELECT A WORD AT THE LEFT FOR EACH BLANK SPACE IN THE QUESTION

1. A STEAM LOCOMOTIVE IS AN _____ COMBUSTION ENGINE.
2. TO HEAT WATER AND MAKE STEAM, WE _____ COAL.
3. THE BURNING PROCESS IS CALLED _____
4. COMBUSTION CANNOT TAKE PLACE UNTIL YOU HAVE BOTH FUEL AND _____.
5. A PISTON SLIDES BACK AND FORTH INSIDE A _____.
6. BACK AND FORTH MOTION IS ALSO CALLED _____ MOTION.
7. A _____ CHANGES RECIPROCATING MOTION TO ROTARY MOTION.

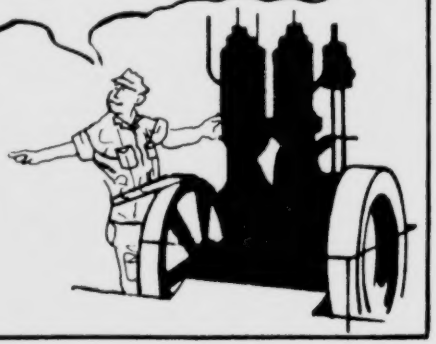
ANSWERS:	7E	6A	5D	4E	3G	2H	1C



THE FIRST INTERNAL COMBUSTION ENGINE LIGHT ENOUGH IN WEIGHT TO BE USEFUL IN CARS AND AIRPLANES WAS THE GASOLINE ENGINE, INVENTED BY A GERMAN NAMED OTTO.

DR. RUDOLPH DIESEL WAS WORKING ON THE DIESEL ENGINE AT THE SAME TIME.

SINCE THE DIESEL ENGINE IS SIMILAR TO THE GASOLINE ENGINE IN MANY WAYS, LET'S LOOK AT THE COMMON GASOLINE ENGINE FIRST.



MOST AUTOMOBILE ENGINES WORK ON A 4-STROKE CYCLE

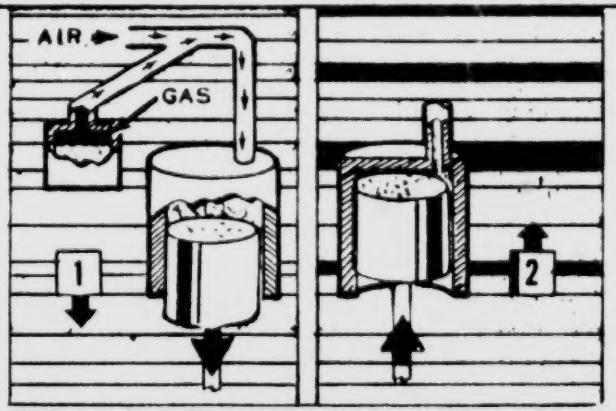
A CYCLE IS ONE COMPLETE SEQUENCE OF EVENTS
ONE DAY IS A CYCLE

THE EVENTS ARE - SUNRISE, DAY, SUNSET AND NIGHT

A PISTON CAN MOVE EITHER I
OF THE CYLINDER. EACH MO OR OUT
IS CALLE MENT
STROK A

A GASOLINE ENGINE ALSO HAS 4 E
FOR EACH CYCLE. EACH EVENT I ENTS
A STROKE CALLED

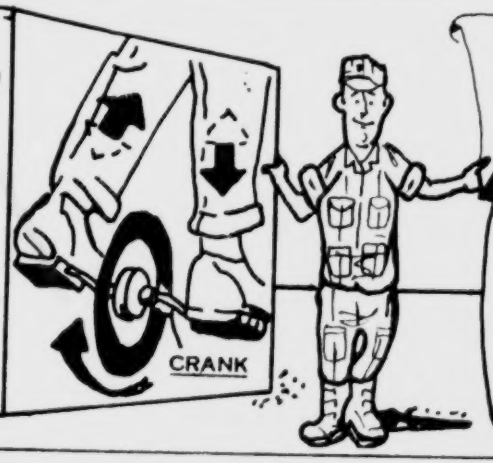
WE START WITH THE PISTON RAISED, THEN PULL IT DOWN TO SUCK IN A MIXTURE OF GASOLINE AND AIR. THIS FIRST DOWNWARD STROKE IS CALLED THE INTAKE STROKE



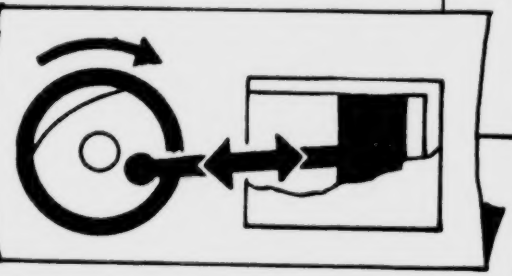
NOW THE PISTON MOVES UPWARD INTO THE UPPER PART OF CLOSED CYLINDER WHERE THE MIXTURE IS SQUEEZED INTO A TINY SPACE. THIS IS CALLED THE COMPRESSION STROKE

WE WON'T EXPLAIN THE FUEL OR VALVE SYSTEM YET; JUST IMAGINE THAT THE CYLINDER IS FILLED WITH A FUEL/AIR MIXTURE NOW.

YOUR LEGS FURNISHED RECIPROCATING, OR BACK-AND-FORTH MOTION, BUT THE CRANKS TO WHICH THE PEDALS WERE ATTACHED CONVERTED IT TO ROTARY, OR 'ROUND AND 'ROUND POWER.



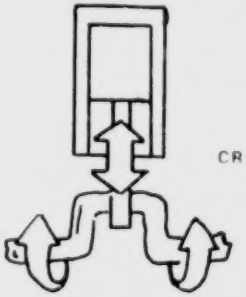
THE WHEEL OF A LOCOMOTIVE ACTS AS A CRANK AND CHANGES RECIPROCATING MOTION TO ROTARY MOTION.



ANOTHER WAY OF MAKING A CRANK IS TO PUT IT IN THE MIDDLE OF A SHAFT

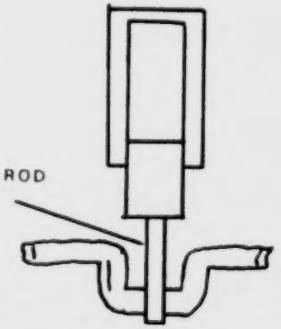
THIS CRANK WILL CHANGE RECIPROCATING MOTION

INTO ROTARY MOTION WHILE THE ENGINE'S PISTON GOES BACK AND FORTH THE CRANKSHAFT WILL GO 'ROUND AND 'ROUND



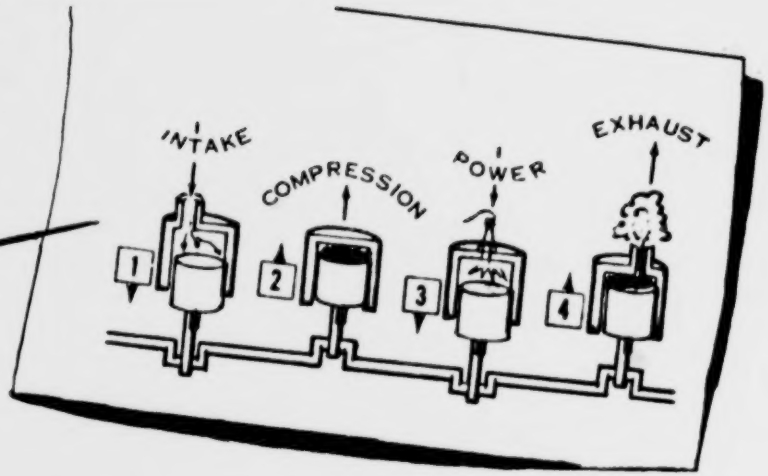
CRANKSHAFT

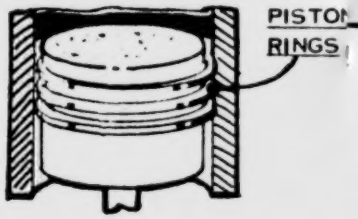
CONNECTING ROD



THE SLIDING PISTON IS CONNECTED TO THE CRANKSHAFT BY A CONNECTING ROD

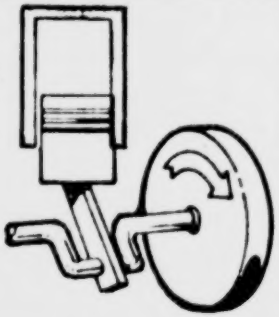
IF WE LOOK AT THEM IN A ROW
ONE AFTER THE OTHER, WE SEE
THE FOUR STROKES -- DOV N, UP,
DOWN, UP





THE PISTON FITS LOOSELY IN THE CYLINDER SO IT WILL SLIDE FREELY. FLEXIBLE METAL RINGS CALLED PISTON RINGS ARE FITTED AROUND IT TO KEEP GASES FROM LEAKING PAST THE PISTON.

IF ONLY 1 STROKE OUT OF 4 IS A POWER STROKE, WE NEED A WAY OF 'STORING' THIS ENERGY TO KEEP THE CRANKSHAFT TURNING.



A HEAVY FLYWHEEL HELPS THE CRANKSHAFT 'COAST' THROUGH THE OTHER 3 STROKES.

WE'VE SHOWN A FUEL MIXTURE ENTERING THE CYLINDERS

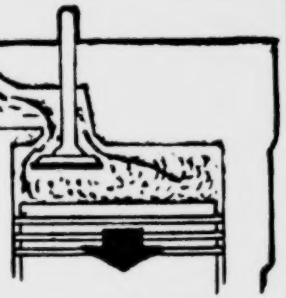
AND EXHAUST GAS LEAVING DURING THE 4-STROKE CYCLE,

BUT WE HAVEN'T MENTIONED VALVES YET.

A KITCHEN FAUCET OPENS AND CLOSES TO CONTROL THE FLOW OF WATER

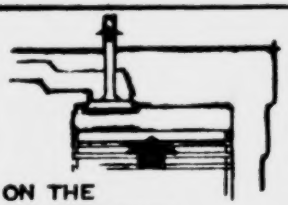
A VALVE CONTAINS A MOVABLE PART THAT OPENS OR SHUTS A PASSAGEWAY

AIR AND FUEL



INTAKE

IN AN ENGINE WE MUST HAVE AN OPENING THROUGH WHICH AIR AND FUEL CAN BE SUCKED INTO THE CYLINDER ON THE INTAKE STROKE.

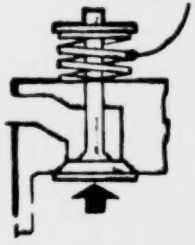


ON THE COMPRESSION STROKE THIS VALVE MUST CLOSE AND SEAL TIGHTLY, SINCE THE PRESSURE WILL BE VERY HIGH.

COMPRESSION

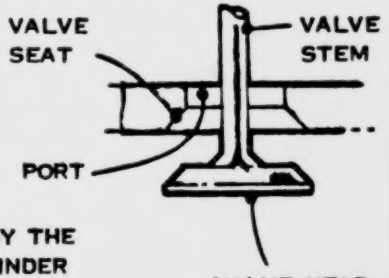
IF WE LOOK CLOSELY AT THE VALVE WE CAN SEE HOW IT FITS INTO THE OPENING OR VALVE PORT LIKE A CORK FITS INTO A BOTTLE.

VALVE SPRING



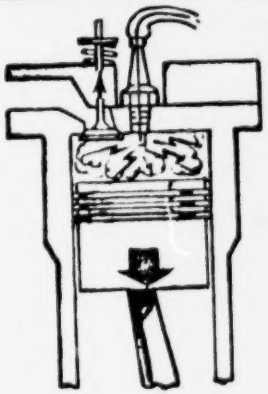
THE VALVE IS CLOSED BY THE VALVE SPRING, AND CYLINDER PRESSURE SEALS IT TIGHTLY.

IT'S EASIER TO TALK ABOUT VALVES IF WE LEARN THE NAMES OF VALVE PARTS.



THE INTAKE VALVE REMAINS CLOSED WHEN THE AIR/ FUEL MIXTURE IS IGNITED AND THE PISTON MOVES DOWNWARD ON THE POWER STROKE.

POWER

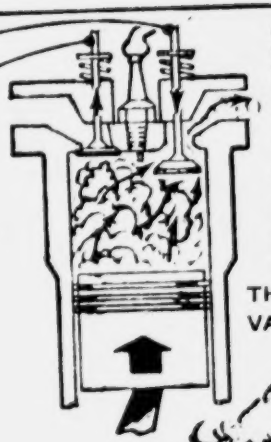


EXHAUST VALVE

INTAKE VALVE

AFTER THE PISTON MOVES DOWNWARD ON THE POWER STROKE IT MOVES BACK UP AGAIN.

THE CYLINDER IS NOW FILLED WITH BURNED GASES THAT MUST BE REMOVED, OR EXHAUSTED.

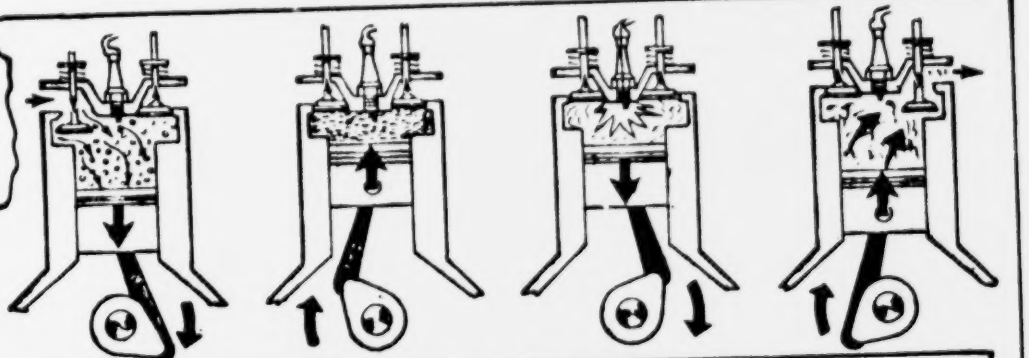


AN EXHAUST VALVE MUST BE ADDED TO THE ENGINE.

THE EXHAUST VALVE OPENS ON THE EXHAUST STROKE.

THE INTAKE VALVE REMAINS CLOSED.

NOW WE'LL REPAIR THE 4-STROKE CYCLE SO YOU CAN SEE THE ACTION OF BOTH THE INTAKE AND THE EXHAUST VALVES ON EVERY STROKE.



INTAKE | COMPRESSION | POWER | EXHAUST

NAME EACH STROKE OF THE 4–STROKE CYCLE AND TELL WHETHER THE VALVES ARE OPEN OR CLOSED.

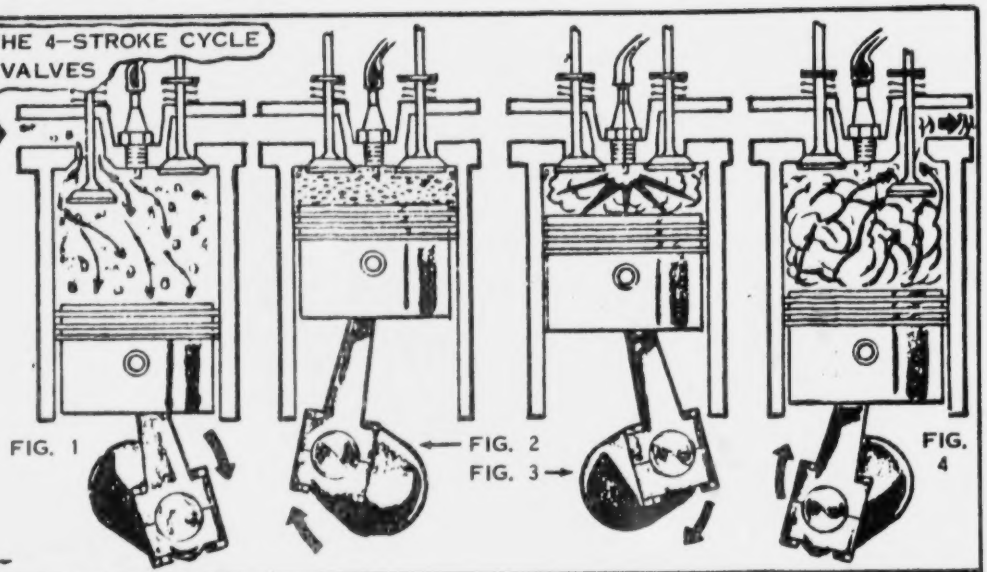
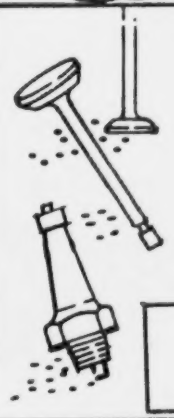


FIG. 1 IS THE _____ STROKE. THE INTAKE VALVE IS _____ (OPEN/CLOSED) AND THE EXHAUST VALVE IS _____ (OPEN/CLOSED).

FIG. 2 IS THE _____ STROKE. THE INTAKE VALVE IS _____ AND THE EXHAUST VALVE IS _____.

FIG. 3 IS THE _____ STROKE. THE INTAKE VALVE IS _____ AND THE EXHAUST VALVE IS _____.

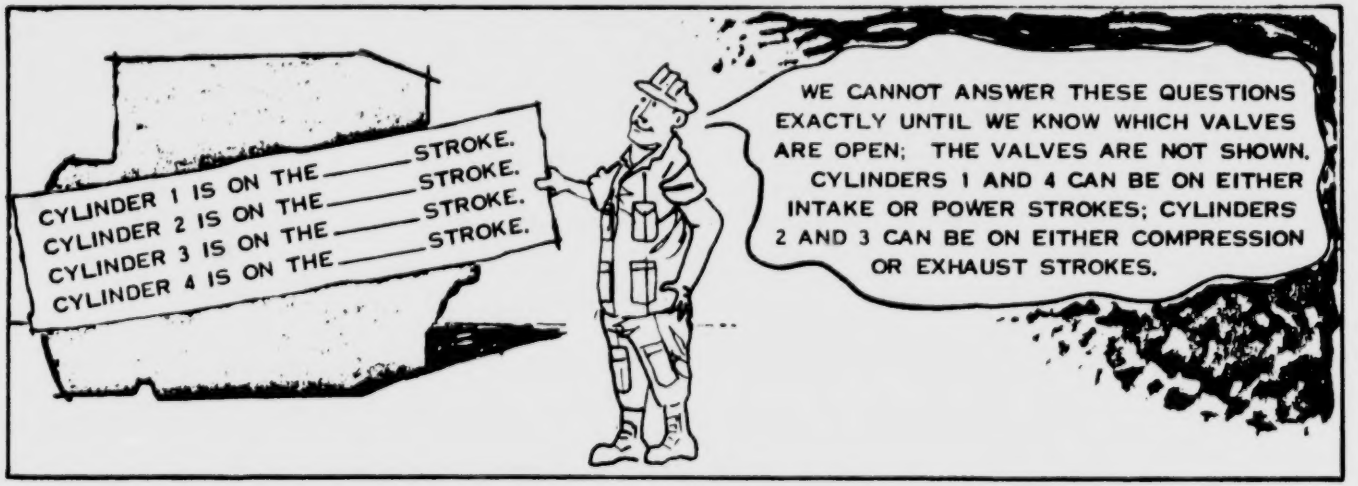
FIG. 4 IS THE _____ STROKE. THE INTAKE VALVE IS _____ AND THE EXHAUST VALVE IS _____.



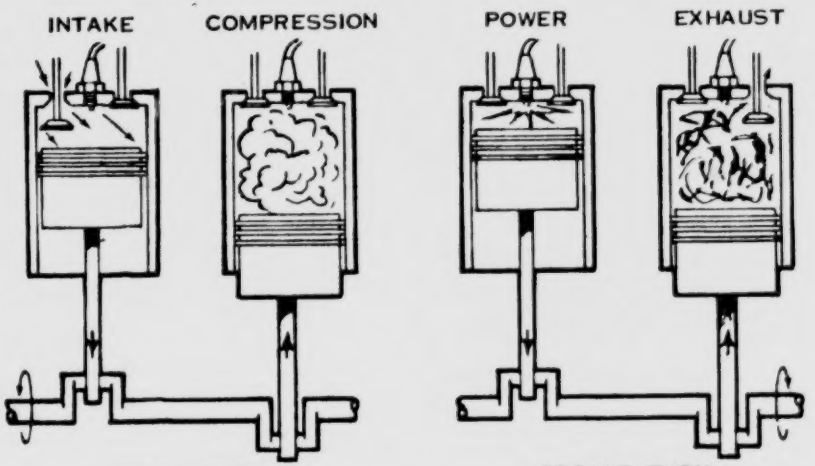
ANSWER

1. INTAKE: OPEN, CLOSED
2 COMPRESSION: CLOSED, CLOSED
3 POWER, CLOSED, CLOSED
4 EXHAUST, CLOSED, OPEN

4-STROKE ENGINES USUALLY HAVE 4 OR MORE CYLINDERS, CONNECTED SO THAT EACH ONE DELIVERS ONE POWER STROKE DURING ONE COMPLETE CYCLE.
LOOK AT THE DRAWING AND IDENTIFY THE STROKES -- INTAKE -- COMPRESSION -- POWER -- EXHAUST
1
2
3
4


CYLINDER 1 IS ON THE ____ STROKE.
CYLINDER 2 IS ON THE ____ STROKE.
CYLINDER 3 IS ON THE ____ STROKE.
CYLINDER 4 IS ON THE ____ STROKE.
WE CANNOT ANSWER THESE QUESTIONS EXACTLY UNTIL WE KNOW WHICH VALVES ARE OPEN; THE VALVES ARE NOT SHOWN. CYLINDERS 1 AND 4 CAN BE ON EITHER INTAKE OR POWER STROKES; CYLINDERS 2 AND 3 CAN BE ON EITHER COMPRESSION OR EXHAUST STROKES.

FOR EACH CYCLE THE CRANKSHAFT MAKES TWO TURNS, AND THE INLET AND EXHAUST VALVES OPEN ONCE.



FIRST TURN

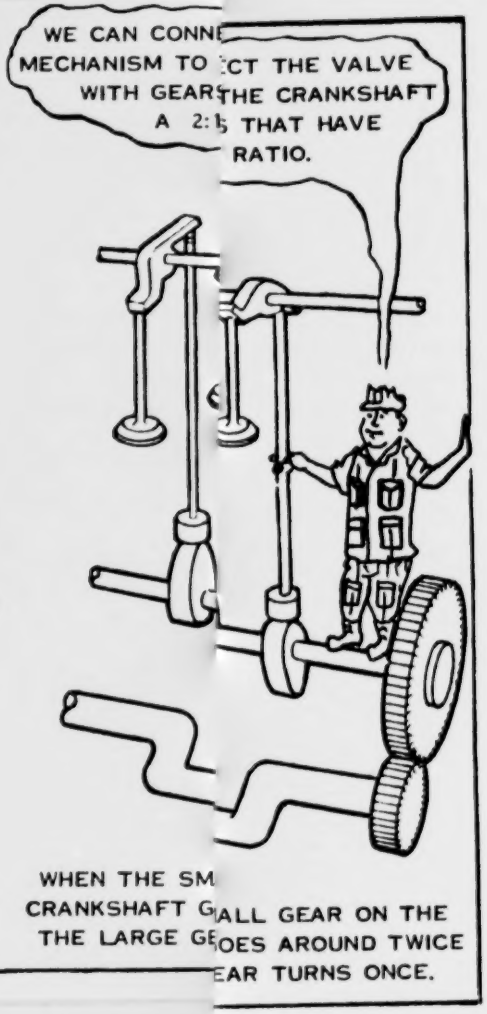
SECOND TURN

DURING THE FIRST REVOLUTION THE INLET VALVE IS OPEN ON THE INTAKE STROKE.

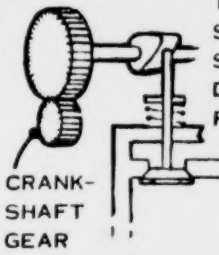
DURING THE SECOND REVOLUTION THE EXHAUST VALVE IS OPEN ON THE EXHAUST STROKE.

DURING THE COMPRESSION AND POWER STROKES BOTH VALVES REMAIN CLOSED

THE CRANKSHAFT MUST MAKE 2 TURNS OR REVOLUTIONS TO COMPLETE ONE 4-STROKE CYCLE.

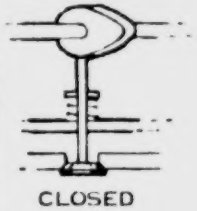


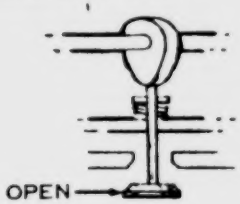
WHEN THE SM
CRANKSHAFT G
THE LARGE GE
ALL GEAR ON THE
OES AROUND TWICE
EAR TURNS ONCE.



THE VALVE IS CLOSED BY A VALVE SPRING, AND IS OPENED BY AN EAR-SHAPED LUMP ON A SHAFT THAT PUSHES DOWN ON THE VALVE DURING PART OF ITS REVOLUTION. THE SHAFT IS CALLED A CAM-SHAFT, AND THE VALVE IS OPENED BY A CAM.

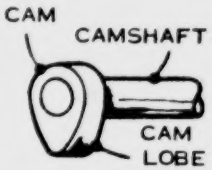
THE POSITION OF THE LOBE DETERMINES WHEN THE VALVE WILL BE OPEN.



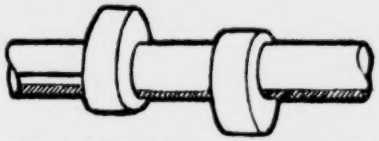


THE TEETH ON THE GEARS LOCK THE PISTONS AND THE VALVES TOGETHER, SO THEY ALWAYS OPERATE IN THE SAME SEQUENCE. SINCE THESE GEARS DETERMINE THE TIME IN THE CYCLE DURING WHICH THE VALVES ARE OPEN, THEY ARE CALLED TIMING GEARS.

A WOMAN ATTACHES AN EARRING TO HER EAR LOBE.
THE PROJECTING PART OF A CAM IS ALSO CALLED A LOBE.

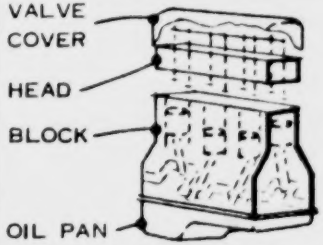


ONE CAMSHAFT CAN OPEN BOTH INTAKE AND EXHAUST VALVES. EACH VALVE IS USUALLY OPENED BY A SEPARATE CAM.



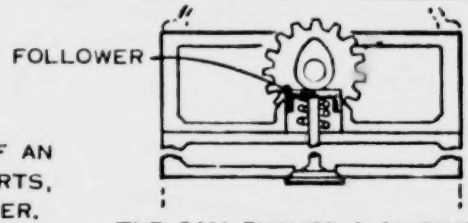
HOW MANY CAMS WOULD THERE BE ON A CAMSHAFT FOR A 4-CYLINDER ENGINE?

eight

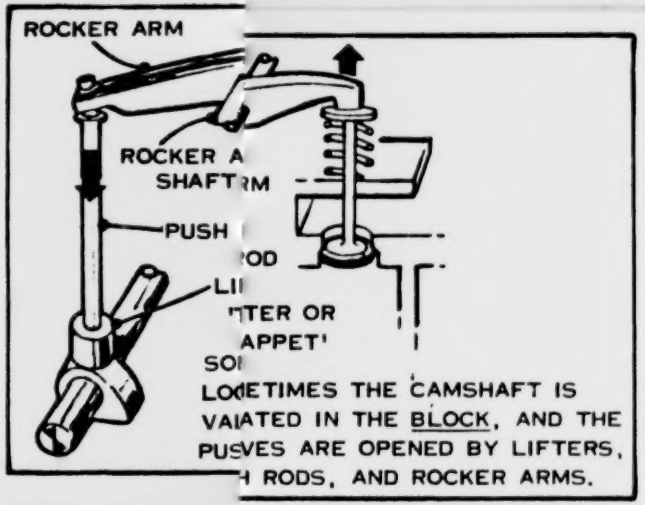


THE CAST METAL FRAME OF AN ENGINE IS MADE IN TWO PARTS, WHICH ARE BOLTED TOGETHER. THE UPPER PART THAT CONTAINS THE VALVES IS CALLED THE HEAD. THE LOWER PART IS CALLED THE BLOCK.

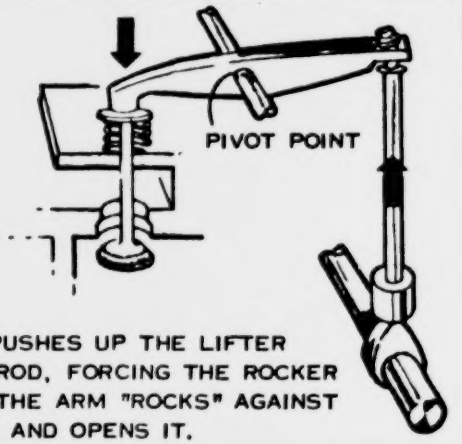
MOST ENGINES ARE " VALVE-IN-HEAD " ENGINES. WHEN THE CAMSHAFT IS IN THE HEAD, IT IS CALLED AN OVERHEAD CAMSHAFT.



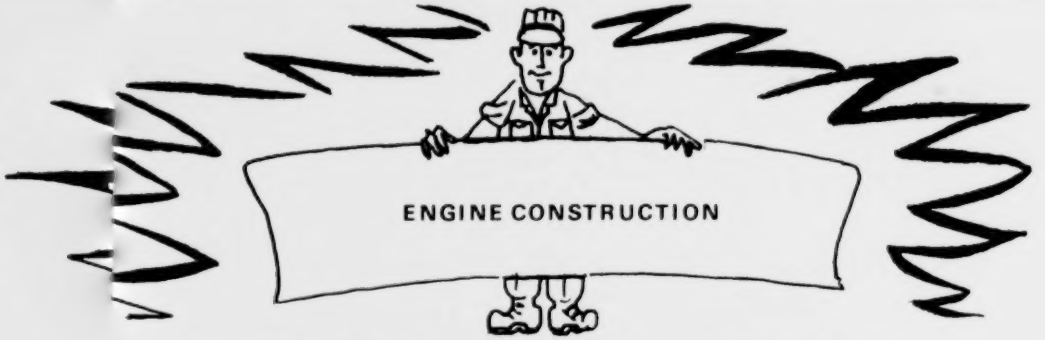
THE CAM PUSHES A SLIDING PART THAT IN TURN PUSHES THE VALVE STEM. THIS PART IS CALLED A FOLLOWER.



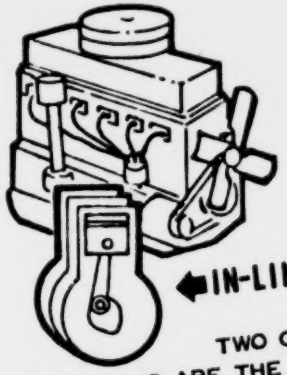
SO
LOMETIMES THE CAMSHAFT IS
VAIATED IN THE BLOCK, AND THE
PUSVES ARE OPENED BY LIFTERS,
H RODS, AND ROCKER ARMS.



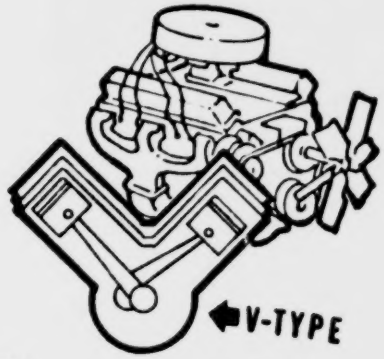
THE CAM PUSHES UP THE LIFTER AND PUSH ROD, FORCING THE ROCKER ARM UP. THE ARM "ROCKS" AGAINST THE VALVE AND OPENS IT.



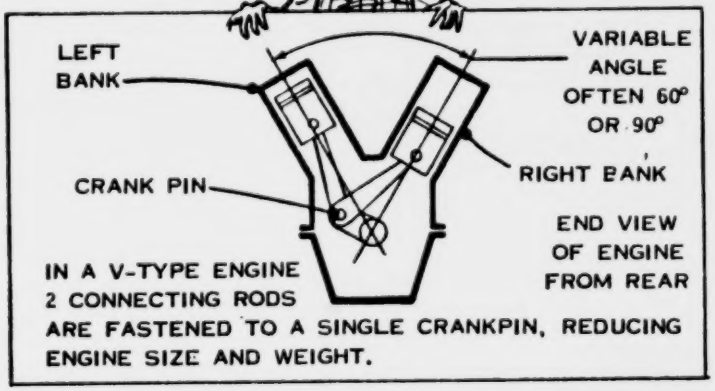
THERE ARE MANY VARIATIONS IN ENGINE CONSTRUCTION, BUT THE BASIC PARTS OF MOST 4-STROKE CYCLE ENGINES ARE SIMILAR. THE MECHANICAL PRINCIPLES AND TERMINILIGY THAT YOU HAVE LEARNED WILL BE USEFUL WHEN WE EXPLAIN THE DIESEL ENGINE.



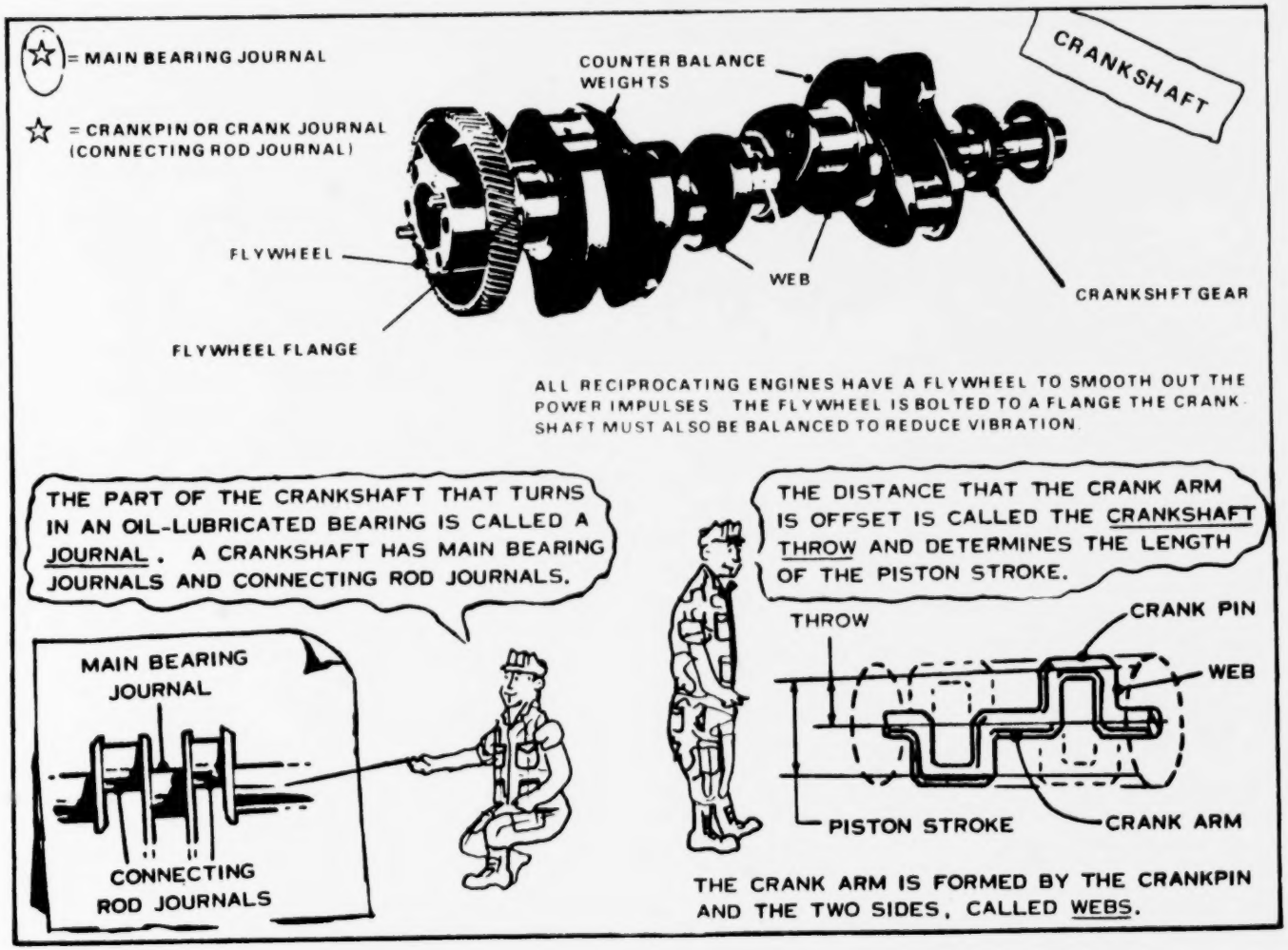
TWO COMMON ENGINE DESIGNS ARE THE IN-LINE, IN WHICH THE CYLINDERS ARE LINED UP IN A SINGLE ROW - - - -

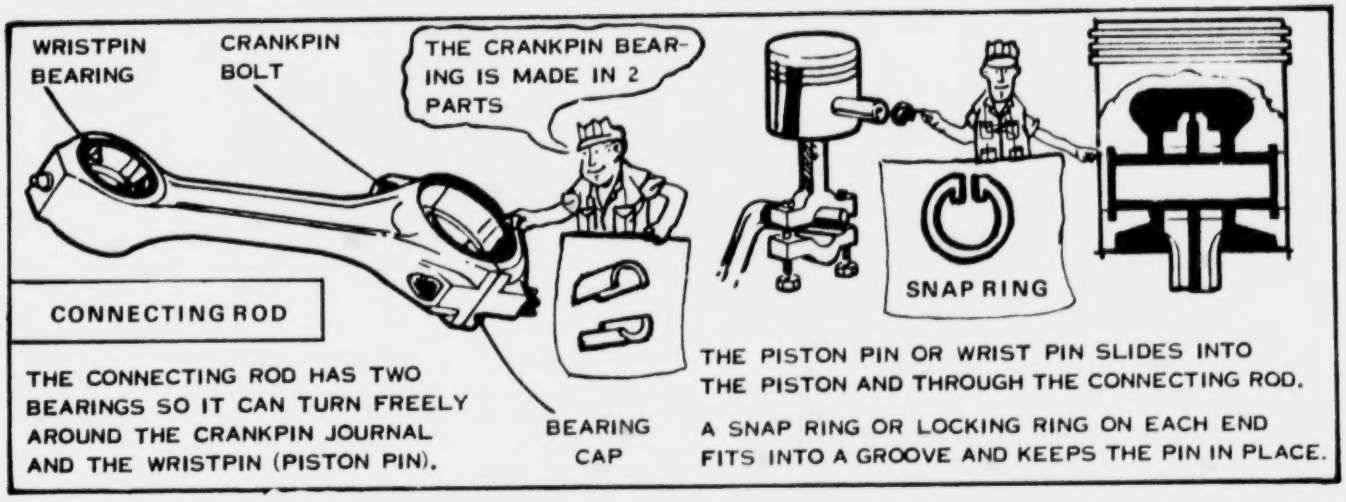


- - AND THE V-TYPE ENGINE, IN WHICH THE CYLINDERS FORM 2 ROWS OR "BANKS."



IN A V-TYPE ENGINE 2 CONNECTING RODS ARE FASTENED TO A SINGLE CRANKPIN, REDUCING ENGINE SIZE AND WEIGHT.


= MAIN BEARING JOURNAL
= CRANKPIN OR CRANK JOURNAL (CONNECTING ROD JOURNAL)
CRANKSHAFT
COUNTER BALANCE WEIGHTS
FLYWHEEL
WEB
CRANKSHFT GEAR
FLYWHEEL FLANGE
ALL RECIPROCATING ENGINES HAVE A FLYWHEEL TO SMOOTH OUT THE POWER IMPULSES. THE FLYWHEEL IS BOLTED TO A FLANGE THE CRANK-SHAFT MUST ALSO BE BALANCED TO REDUCE VIBRATION.
THE PART OF THE CRANKSHAFT THAT TURNS IN AN OIL-LUBRICATED BEARING IS CALLED A JOURNAL. A CRANKSHAFT HAS MAIN BEARING JOURNALS AND CONNECTING ROD JOURNALS.
MAIN BEARING JOURNAL
CONNECTING ROD JOURNALS
THE DISTANCE THAT THE CRANK ARM IS OFFSET IS CALLED THE CRANKSHAFT THROW AND DETERMINES THE LENGTH OF THE PISTON STROKE.
THROW
CRANK PIN
WEB
PISTON STROKE
CRANK ARM
THE CRANK ARM IS FORMED BY THE CRANKPIN AND THE TWO SIDES, CALLED WEBS.



CONNECTING ROD

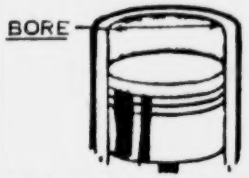
THE CONNECTING ROD HAS TWO BEARINGS SO IT CAN TURN FREELY AROUND THE CRANKPIN JOURNAL AND THE WRISTPIN (PISTON PIN).

THE PISTON PIN OR WRIST PIN SLIDES INTO THE PISTON AND THROUGH THE CONNECTING ROD.

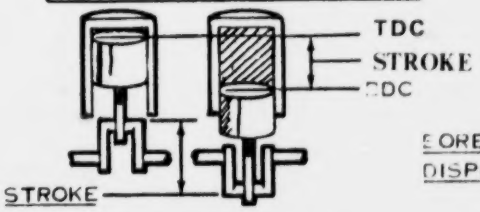
A SNAP RING OR LOCKING RING ON EACH END FITS INTO A GROOVE AND KEEPS THE PIN IN PLACE.

DISPLACEMENT

THE DIAMETER OF THE CYLINDER IS CALLED THE BORE



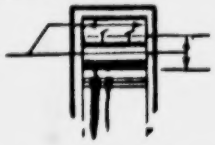
ENGINE SPEED AND POWER ARE PARTLY DETERMINED BY CYLINDER SIZE AND CONNECTING ROD STROKE, COMMONLY CALLED DISPLACEMENT.



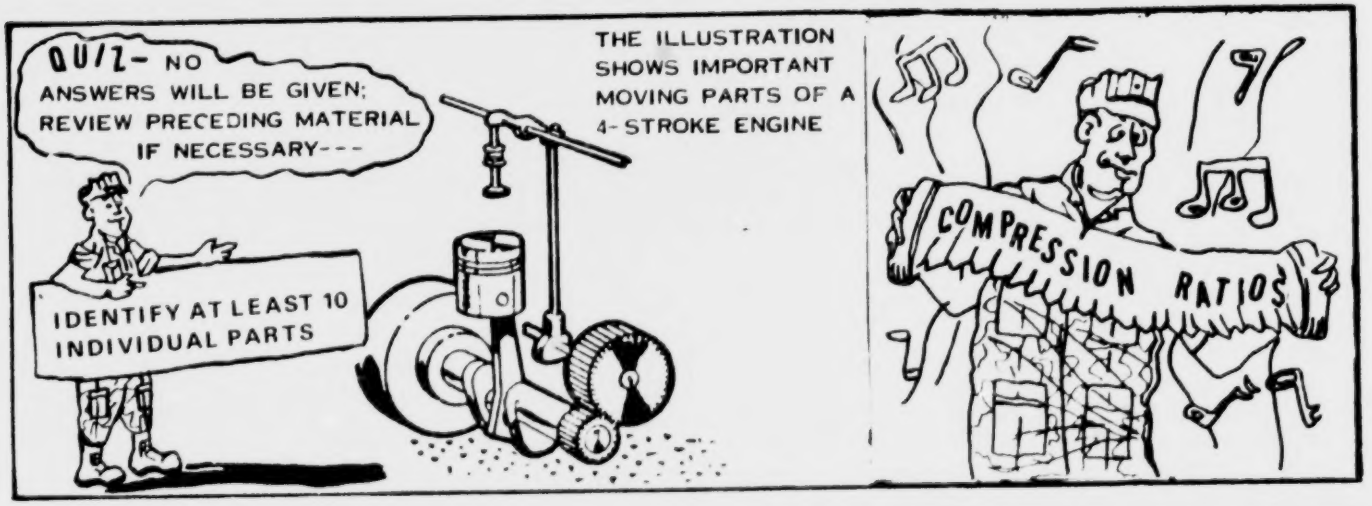
THE CRANKSHAFT THROW DETERMINES THE DISTANCE THE CONNECTING ROD AND PISTON CAN MOVE. THIS DISTANCE IS CALLED THE STROKE.

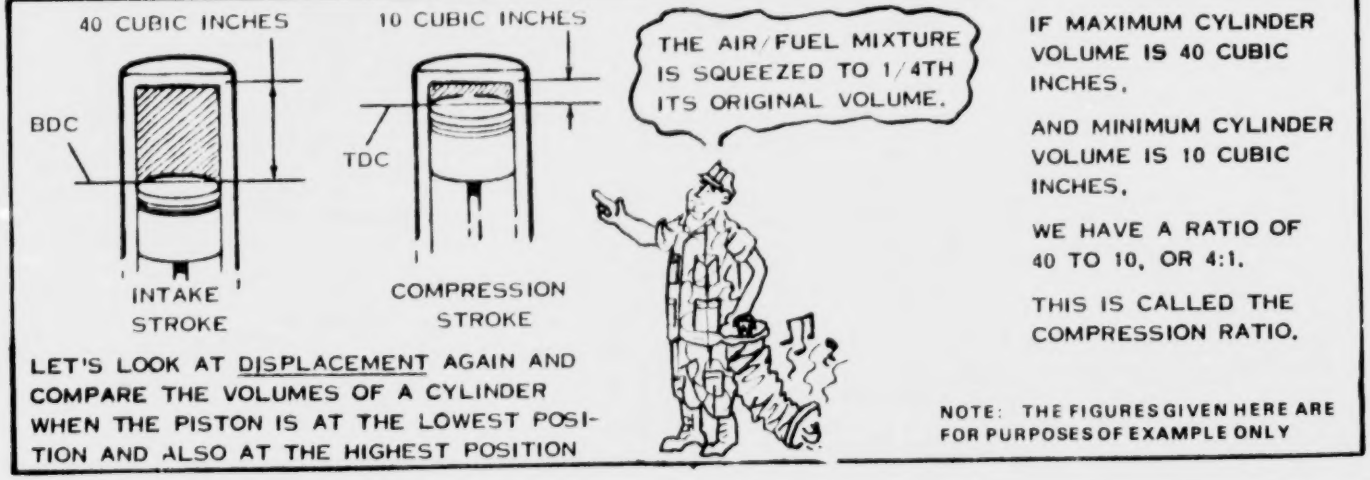
BORE AREA TIMES STROKE WILL GIVE YOU THE DISPLACEMENT OR "WORKING" VOLUME OF THE CYLINDER, SOMETIMES CALLED SWEPT VOLUME OR STROKE VOLUME.

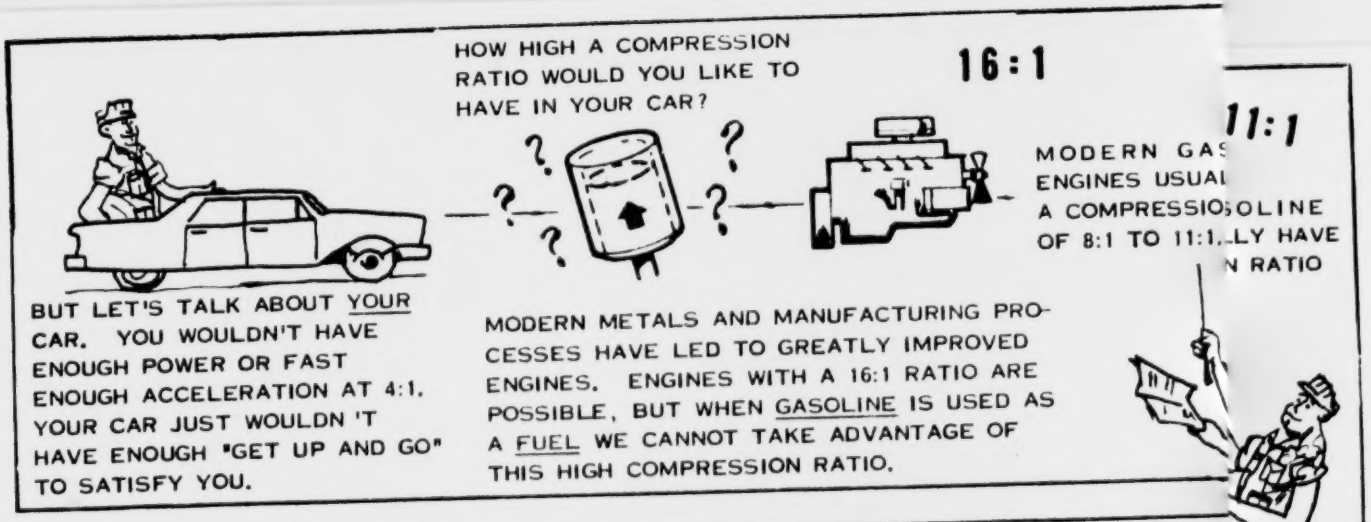
BORE AREA X STROKE = DISPLACEMENT

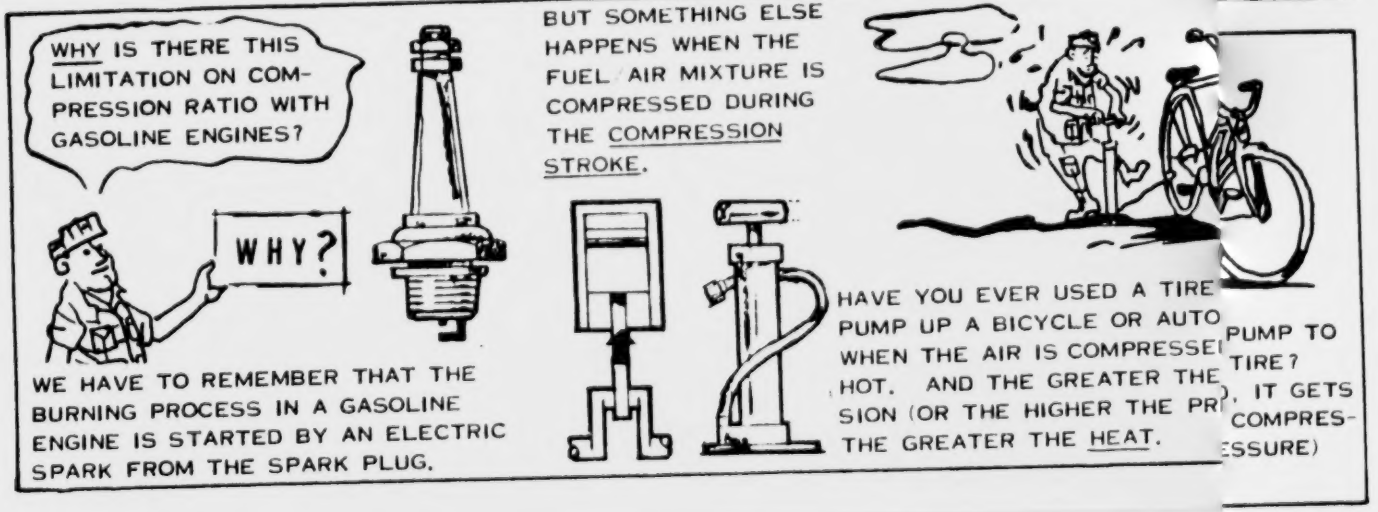


THE CRANKSHAFT THROW DETERMINES THE STROKE. WHEN THE PISTON IS AT THE TOP OF THE STROKE, WE SAY THAT IT IS AT TOP DEAD CENTER. WHEN IT IS AT THE BOTTOM, WE SAY THAT IT IS AT BOTTOM DEAD CENTER.


QUIZ- NO ANSWERS WILL BE GIVEN; REVIEW PRECEDING MATERIAL IF NECESSARY---
IDENTIFY AT LEAST 10 INDIVIDUAL PARTS
THE ILLUSTRATION SHOWS IMPORTANT MOVING PARTS OF A 4-STROKE ENGINE
COMPRESSION RATIOS

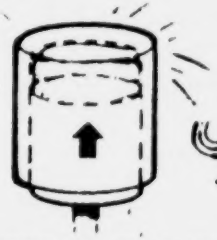

40 CUBIC INCHES
10 CUBIC INCHES
BDC
TDC
INTAKE STROKE
COMPRESSION STROKE
THE AIR/FUEL MIXTURE IS SQUEEZED TO 1/4TH ITS ORIGINAL VOLUME.
LET'S LOOK AT DISPLACEMENT AGAIN AND COMPARE THE VOLUMES OF A CYLINDER WHEN THE PISTON IS AT THE LOWEST POSITION AND ALSO AT THE HIGHEST POSITION
IF MAXIMUM CYLINDER VOLUME IS 40 CUBIC INCHES,
AND MINIMUM CYLINDER VOLUME IS 10 CUBIC INCHES,
WE HAVE A RATIO OF 40 TO 10, OR 4:1.
THIS IS CALLED THE COMPRESSION RATIO.
NOTE: THE FIGURES GIVEN HERE ARE FOR PURPOSES OF EXAMPLE ONLY


HOW HIGH A COMPRESSION RATIO WOULD YOU LIKE TO HAVE IN YOUR CAR?
16:1
BUT LET'S TALK ABOUT YOUR CAR. YOU WOULDN'T HAVE ENOUGH POWER OR FAST ENOUGH ACCELERATION AT 4:1. YOUR CAR JUST WOULDN 'T HAVE ENOUGH "GET UP AND GO" TO SATISFY YOU.
MODERN METALS AND MANUFACTURING PROCESSES HAVE LED TO GREATLY IMPROVED ENGINES. ENGINES WITH A 16:1 RATIO ARE POSSIBLE, BUT WHEN GASOLINE IS USED AS A FUEL WE CANNOT TAKE ADVANTAGE OF THIS HIGH COMPRESSION RATIO.
11:1
MODERN GAS
ENGINES USUAL
A COMPRESSIO
OF 8:1 TO 11:1.
OLINE
LY HAVE
N RATIO


WHY IS THERE THIS LIMITATION ON COMPRESSION RATIO WITH GASOLINE ENGINES?
WHY?
WE HAVE TO REMEMBER THAT THE BURNING PROCESS IN A GASOLINE ENGINE IS STARTED BY AN ELECTRIC SPARK FROM THE SPARK PLUG.
BUT SOMETHING ELSE HAPPENS WHEN THE FUEL AIR MIXTURE IS COMPRESSED DURING THE COMPRESSION STROKE.
HAVE YOU EVER USED A TIRE
PUMP UP A BICYCLE OR AUTO
WHEN THE AIR IS COMPRESSE
HOT. AND THE GREATER THE
SION (OR THE HIGHER THE PR
THE GREATER THE HEAT.
PUMP TO
TIRE?
. IT GETS
COMPRES-
ESSURE)

COMPRESSING AIR OR A GAS PRODUCES HEAT. THE HIGHER THE PRESSURE, THE GREATER THE HEAT.

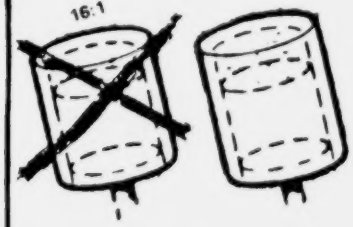
COMPRESSING A FUEL/AIR MIXTURE IN AN ENGINE ALSO PRODUCES HEAT.



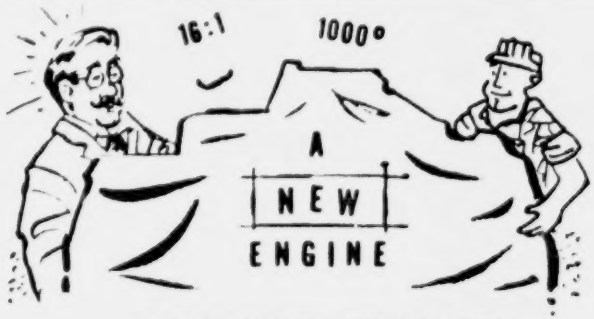
IF THE COMPRESSION RATIO IN AN ENGINE IS TOO HIGH THERE WILL BE SO MUCH HEAT THAT THE FUEL/AIR MIXTURE WILL START BURNING BY ITSELF BEFORE THE ELECTRIC SPARK IGNITES IT.

THIS BURNING BEGINS BEFORE IT SHOULD AND IS CALLED PRE-IGNITION. GASOLINE BURNS VERY EASILY, AND TOO HIGH A COMPRESSION RATIO WILL CAUSE IT TO BURN BY ITSELF.

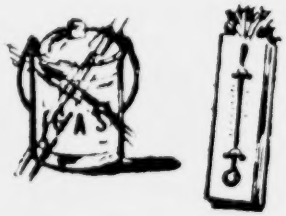
PRE-IGNITION MEANS THAT THE FUEL/AIR MIXTURE BEGINS BURNING BEFORE SPARK IGNITION.



THE COMPRESSION RATIO OF A GASOLINE ENDING ES LIMITED SO THAT HEAT OF COMPRESSION DOES NOT CAUSE PRE-IGNITION.



DR. RUDOLPH DISEL WORKED ALONG DIFFERENT LINES. HE KNEW THAT THE KEY TO AN EFFICIENT AND POWERFUL ENGINE WAS *HIGH COMPRESSION*, SO HE BUILT A HIGH-COMPRESSION ENGINE.



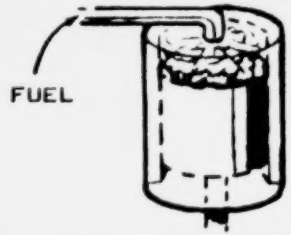
BUT THIS ENGINE COULD NO LONGER BURN AN AIR/FUEL MIXTURE, SINCE THE HEAT OF COMPRESSION ROSE TO ABOUT 1000

ALMOST ANY FUEL WOULD I
BEFORE IT REACHED 1000°, S
NO FUEL WAS ADDED TO TH
ON THE COMPRESSION STRO
ONLY AIR WAS COMPRESSED
THERE WAS NOTHING IN THE
THAT WOULD BURN.

URN
O
E AIR.
KE,
AND
AIR

DIFFERENT

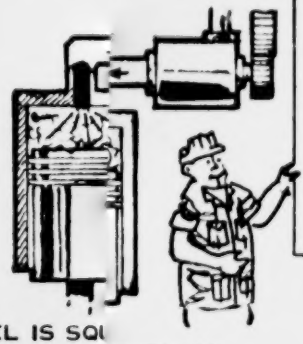
THIS PRINCIPLE IS IMPORTANT, BECAUSE WE USE IT TO MAKE AN ENTIRELY DIFFERENT KIND OF ENGINE.



IF FUEL IS SQUIRTED INTO THE CYLINDER NEAR THE TOP OF THE COMPRESSION STROKE, IT WILL MIX WITH THE 1000° AIR AND START BURNING.

THIS IS CALLED SELF-IGNITION OR SPONTANEOUS IGNITION.

IN AN ENGINE LIKE THIS NO SPARK PLUG IS NEEDED.



INSTEAD, THE FUEL IS SQ
INJECTED INTO THE CYLIN
PROPER TIME DURING THE
GEAR-DRIVEN FUEL PUMP.

IRTED OR
ER AT THE
CYCLE BY A

DIESEL ENGINE

IT GETS ITS POWER FROM THE EXPANSION OF BURNING GASES.

A DIESEL ENGINE DEPENDS ON THE HEAT OF COMPRESSION FOR IGNITION OF THE FUEL.

A LIQUID FUEL THAT CONTAINS MORE HEAT ENERGY THAN GASOLINE IS DIESEL OIL.

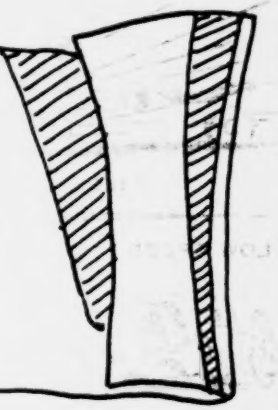
GASOLINE

DIESEL FUEL

DIESEL OIL IS SLOWER BURNING, BUT IT PRODUCES MORE POWER. MOST DIESEL ENGINES OPERATE AT SLOWER SPEEDS, BUT ARE MORE POWERFUL THAN GASOLINE ENGINES.

DIESEL ENGINES ALSO MUST BE HEAVIER AND MORE RUGGEDLY-BUILT THAN GASOLINE ENGINES. THEY'RE NOT AS CHEAP OR AS LIGHT AS GASOLINE ENGINES

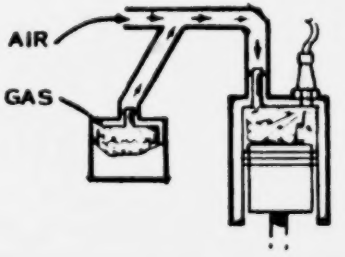
BUT THEY'RE FAR MORE EFFICIENT WHEN WORKING UNDER HEAVY LOADS.



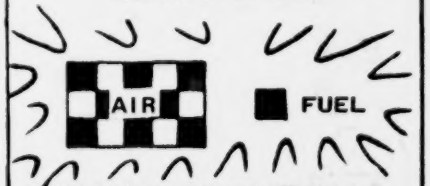
WHY FUEL INJECTION?

THE MOST OBVIOUS ADVANTAGE OF FUEL INJECTION IS TO PERMIT HIGHER AND MORE EFFICIENT COMPRESSION RATIOS. BUT THERE IS ALSO ANOTHER ADVANTAGE, BECAUSE THE AMOUNT OF FUEL INJECTED CAN BE VARIED.

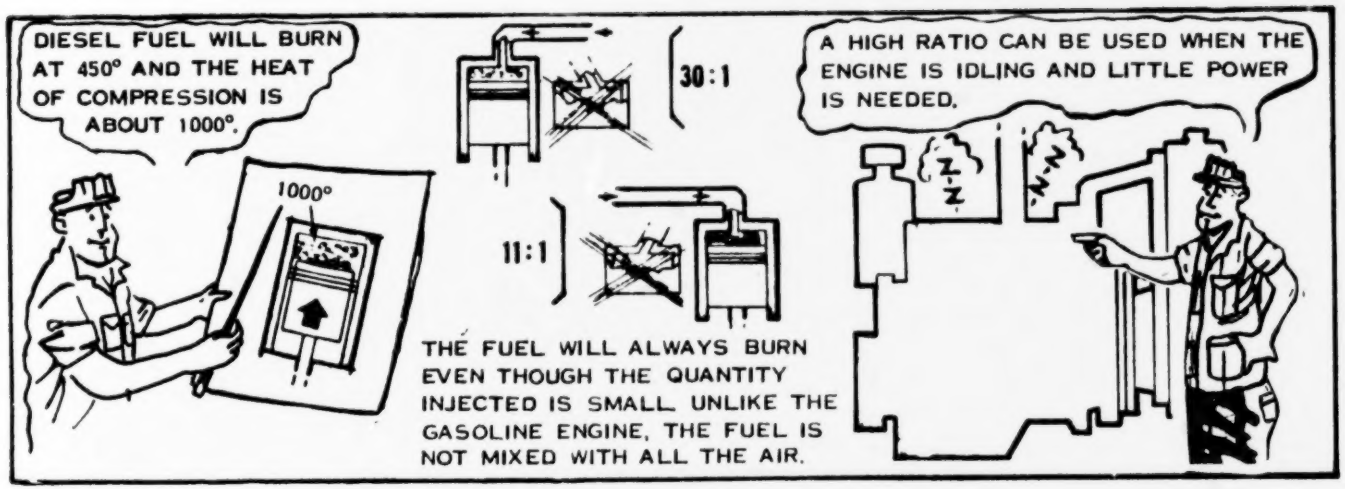
LET'S LOOK AT THE GASOLINE ENGINE AGAIN. THE AIR/FUEL MIXTURE IS IGNITED BY AN ELECTRIC SPARK.

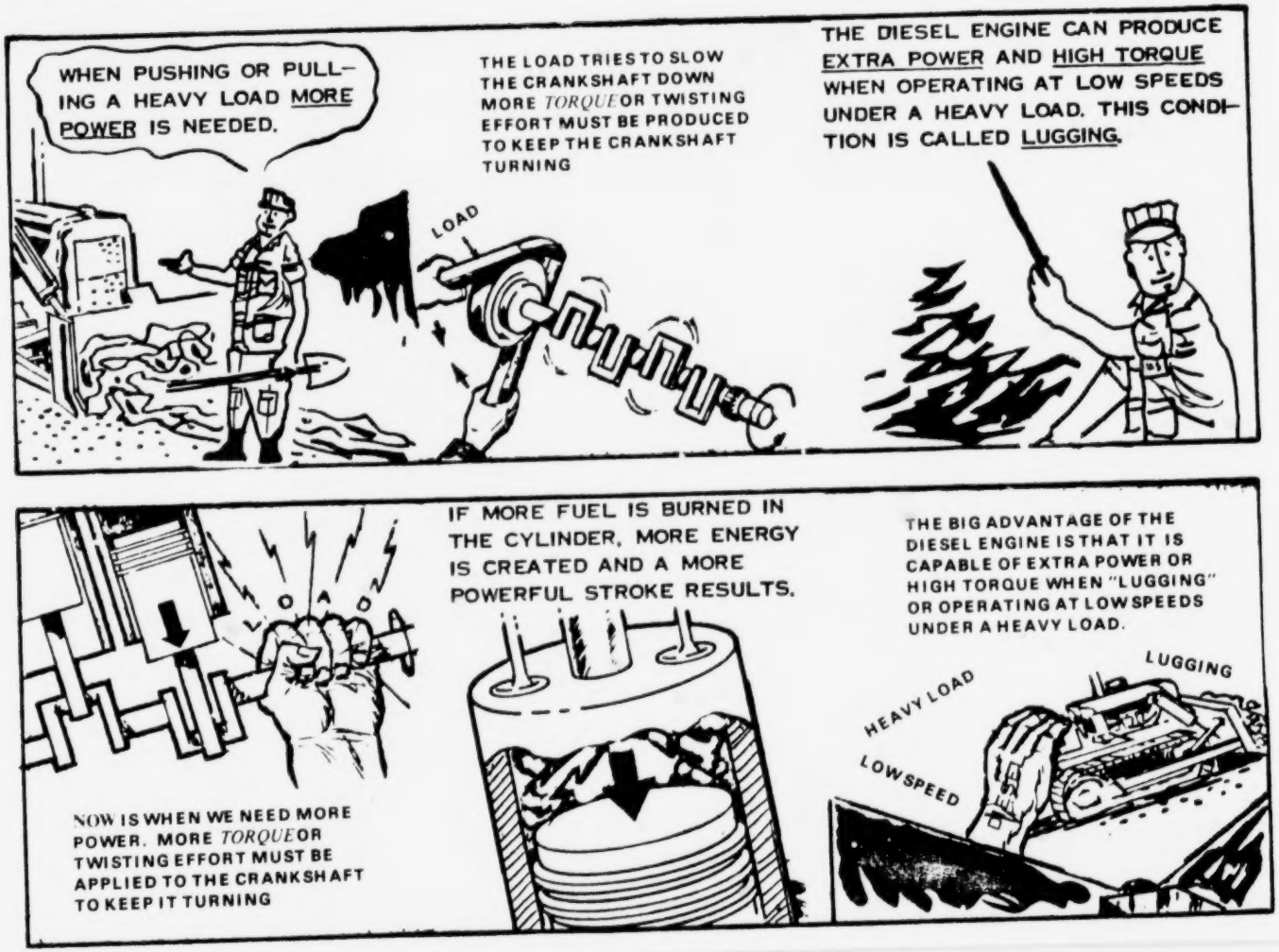


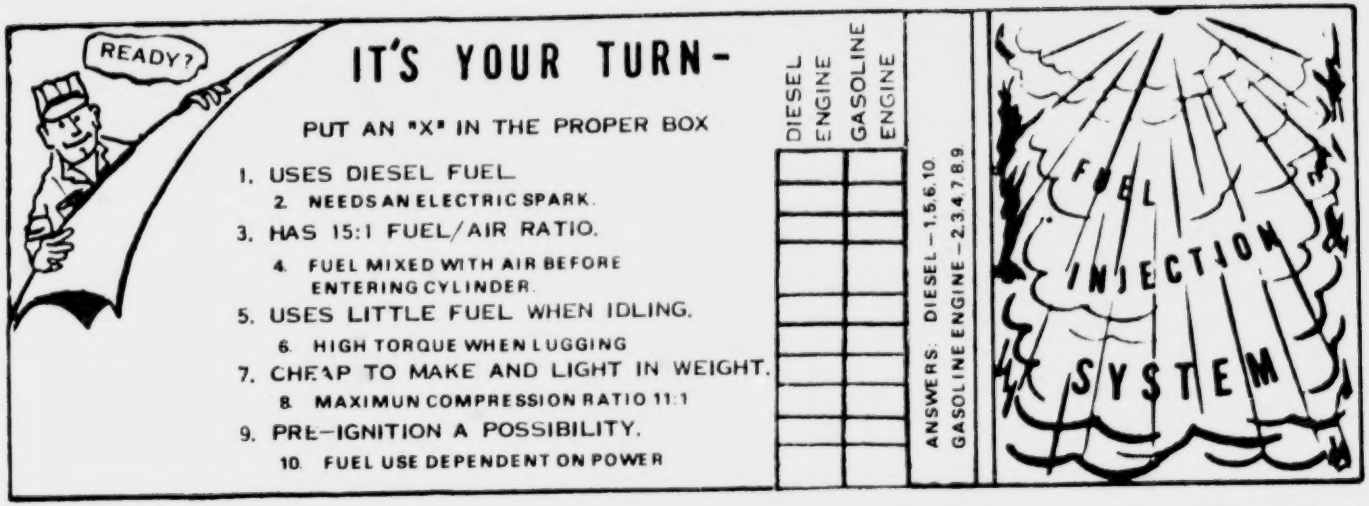
THE ELECTRIC SPARK REQUIRES A FUEL/AIR RATIO THAT IS CLOSE TO 15 PARTS OF AIR AND 1 PART OF FUEL

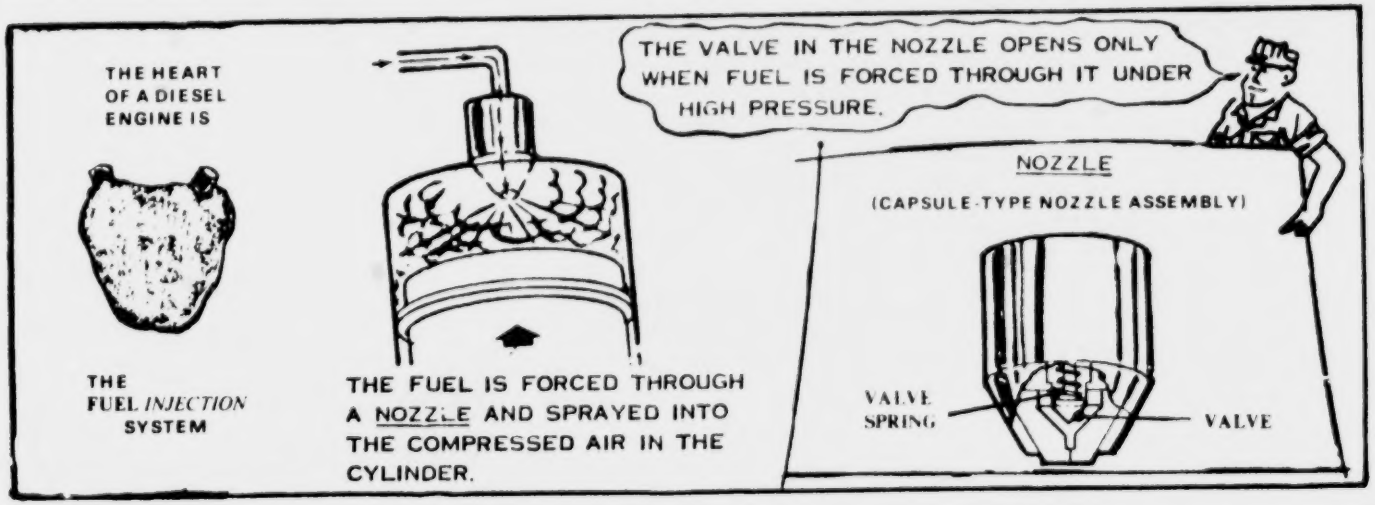


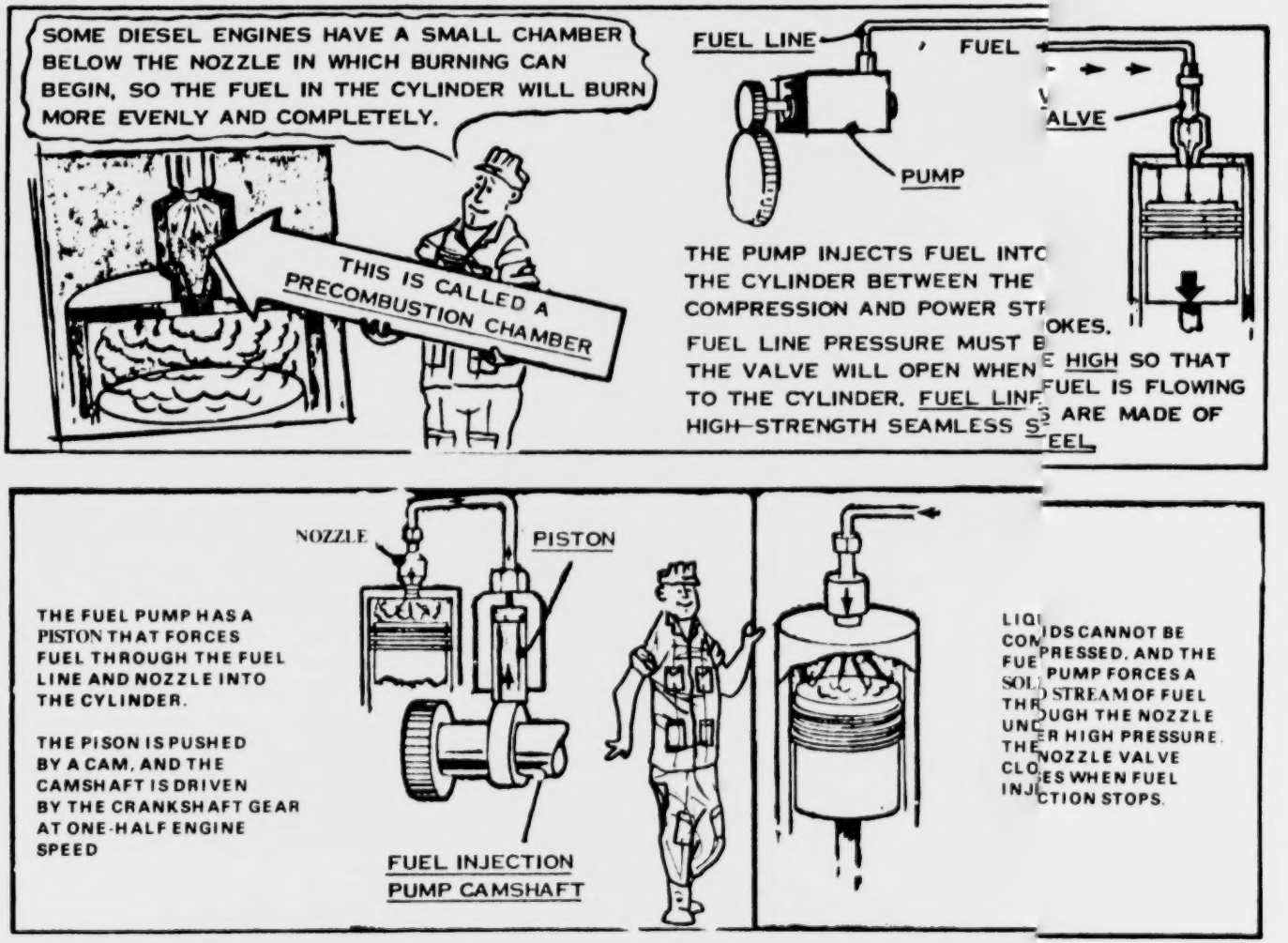
REGARDLESS OF ENGINE SPEED, THE RATIO OF AIR TO FUEL IN A GASOLINE ENGINE IS ABOUT 15:1.

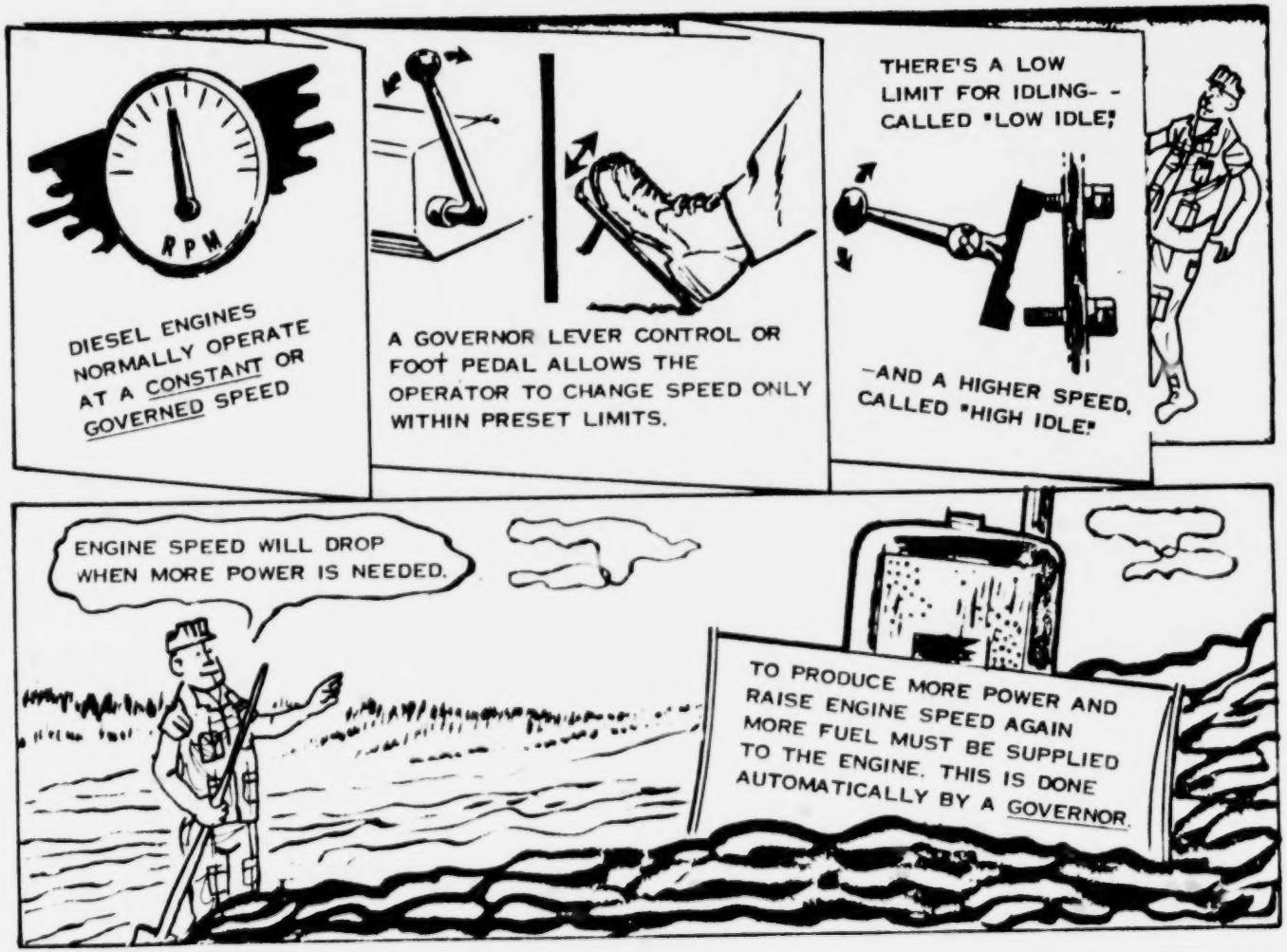

DIESEL FUEL WILL BURN AT 450° AND THE HEAT OF COMPRESSION IS ABOUT 1000°.
1000°
30:1
11:1
THE FUEL WILL ALWAYS BURN EVEN THOUGH THE QUANTITY INJECTED IS SMALL. UNLIKE THE GASOLINE ENGINE, THE FUEL IS NOT MIXED WITH ALL THE AIR.
A HIGH RATIO CAN BE USED WHEN THE ENGINE IS IDLING AND LITTLE POWER IS NEEDED.
Z-Z-Z
Z-Z-Z


WHEN PUSHING OR PULLING A HEAVY LOAD MORE POWER IS NEEDED.
THE LOAD TRIES TO SLOW THE CRANKSHAFT DOWN MORE TORQUE OR TWISTING EFFORT MUST BE PRODUCED TO KEEP THE CRANKSHAFT TURNING
LOAD
THE DIESEL ENGINE CAN PRODUCE EXTRA POWER AND HIGH TORQUE WHEN OPERATING AT LOW SPEEDS UNDER A HEAVY LOAD. THIS CONDITION IS CALLED LUGGING.
LOADS
NOW IS WHEN WE NEED MORE POWER. MORE TORQUE OR TWISTING EFFORT MUST BE APPLIED TO THE CRANKSHAFT TO KEEP IT TURNING
IF MORE FUEL IS BURNED IN THE CYLINDER, MORE ENERGY IS CREATED AND A MORE POWERFUL STROKE RESULTS.
THE BIG ADVANTAGE OF THE DIESEL ENGINE IS THAT IT IS CAPABLE OF EXTRA POWER OR HIGH TORQUE WHEN "LUGGING" OR OPERATING AT LOW SPEEDS UNDER A HEAVY LOAD.
LUGGING
HEAVY LOAD
LOW SPEED


READY?
IT'S YOUR TURN-
PUT AN "X" IN THE PROPER BOX
1. USES DIESEL FUEL.
2. NEEDS AN ELECTRIC SPARK.
3. HAS 15:1 FUEL/AIR RATIO.
4. FUEL MIXED WITH AIR BEFORE ENTERING CYLINDER.
5. USES LITTLE FUEL WHEN IDLING.
6. HIGH TORQUE WHEN LUGGING
7. CHEAP TO MAKE AND LIGHT IN WEIGHT.
8. MAXIMUN COMPRESSION RATIO 11:1
9. PRE-IGNITION A POSSIBILITY.
10. FUEL USE DEPENDENT ON POWER
DIESEL ENGINE
GASOLINE ENGINE
ANSWERS: DIESEL-1.5.6.10.
GASOLINE ENGINE-2.3.4.7.8.9
FUEL
INJECTION
SYSTEM


THE HEART OF A DIESEL ENGINE IS
THE FUEL INJECTION SYSTEM
THE FUEL IS FORCED THROUGH A NOZZLE AND SPRAYED INTO THE COMPRESSED AIR IN THE CYLINDER.
THE VALVE IN THE NOZZLE OPENS ONLY WHEN FUEL IS FORCED THROUGH IT UNDER HIGH PRESSURE.
NOZZLE
(CAPSULE-TYPE NOZZLE ASSEMBLY)
VALVE SPRING
VALVE

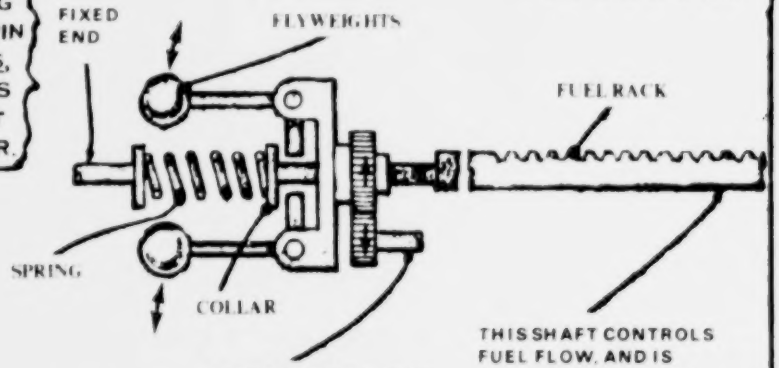

SOME DIESEL ENGINES HAVE A SMALL CHAMBER BELOW THE NOZZLE IN WHICH BURNING CAN BEGIN, SO THE FUEL IN THE CYLINDER WILL BURN MORE EVENLY AND COMPLETELY.
THIS IS CALLED A PRECOMBUSTION CHAMBER
FUEL LINE
FUEL
PUMP
ALVE
THE PUMP INJECTS FUEL INTO
THE CYLINDER BETWEEN THE
COMPRESSION AND POWER ST
OKES.
FUEL LINE PRESSURE MUST B
E HIGH SO THAT
THE VALVE WILL OPEN WHEN
TO THE CYLINDER. FUEL LINE
FUEL IS FLOWING
HIGH-STRENGTH SEAMLESS S
ARE MADE OF
EEL
NOZZLE
PISTON
THE FUEL PUMP HAS A PISTON THAT FORCES FUEL THROUGH THE FUEL LINE AND NOZZLE INTO THE CYLINDER.
THE PISON IS PUSHED BY A CAM, AND THE CAMSHAFT IS DRIVEN BY THE CRANKSHAFT GEAR AT ONE-HALF ENGINE SPEED
FUEL INJECTION PUMP CAMSHAFT
LIQ
CO
FUE
SOL
THR
UNC
THE
CLO
INJ
IDS CANNOT BE
PRESSED, AND THE
PUMP FORCES A
STREAM OF FUEL
UGH THE NOZZLE
R HIGH PRESSURE.
NOZZLE VALVE
ES WHEN FUEL
CTION STOPS.


RPM
DIESEL ENGINES NORMALLY OPERATE AT A CONSTANT OR GOVERNED SPEED
A GOVERNOR LEVER CONTROL OR FOOT PEDAL ALLOWS THE OPERATOR TO CHANGE SPEED ONLY WITHIN PRESET LIMITS.
THERE'S A LOW LIMIT FOR IDLING- - CALLED "LOW IDLE;
-AND A HIGHER SPEED, CALLED "HIGH IDLE."
ENGINE SPEED WILL DROP WHEN MORE POWER IS NEEDED.
TO PRODUCE MORE POWER AND RAISE ENGINE SPEED AGAIN MORE FUEL MUST BE SUPPLIED TO THE ENGINE. THIS IS DONE AUTOMATICALLY BY A GOVERNOR.

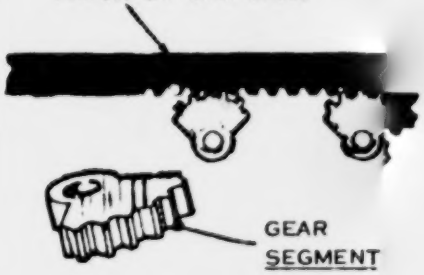
A GOVERNOR IS A SPEED-SENS
MOST GOVERNORS ARE SIMPLE
OF A SPRING, ROTATING WEIGH
AND FLY OUTWARD--CALLED
AND A SLIDING SHAFT. THE SP
ON ONE SIDE OF A COLLAR OR
AND THE FLYWEIGHTS PUSH O

ING DEVICE.
CONSISTING
TS THAT SPIN
FLYWEIGHTS,
RING PUSHES
THE SHAFT
N THE OTHER.

GOVERNORS



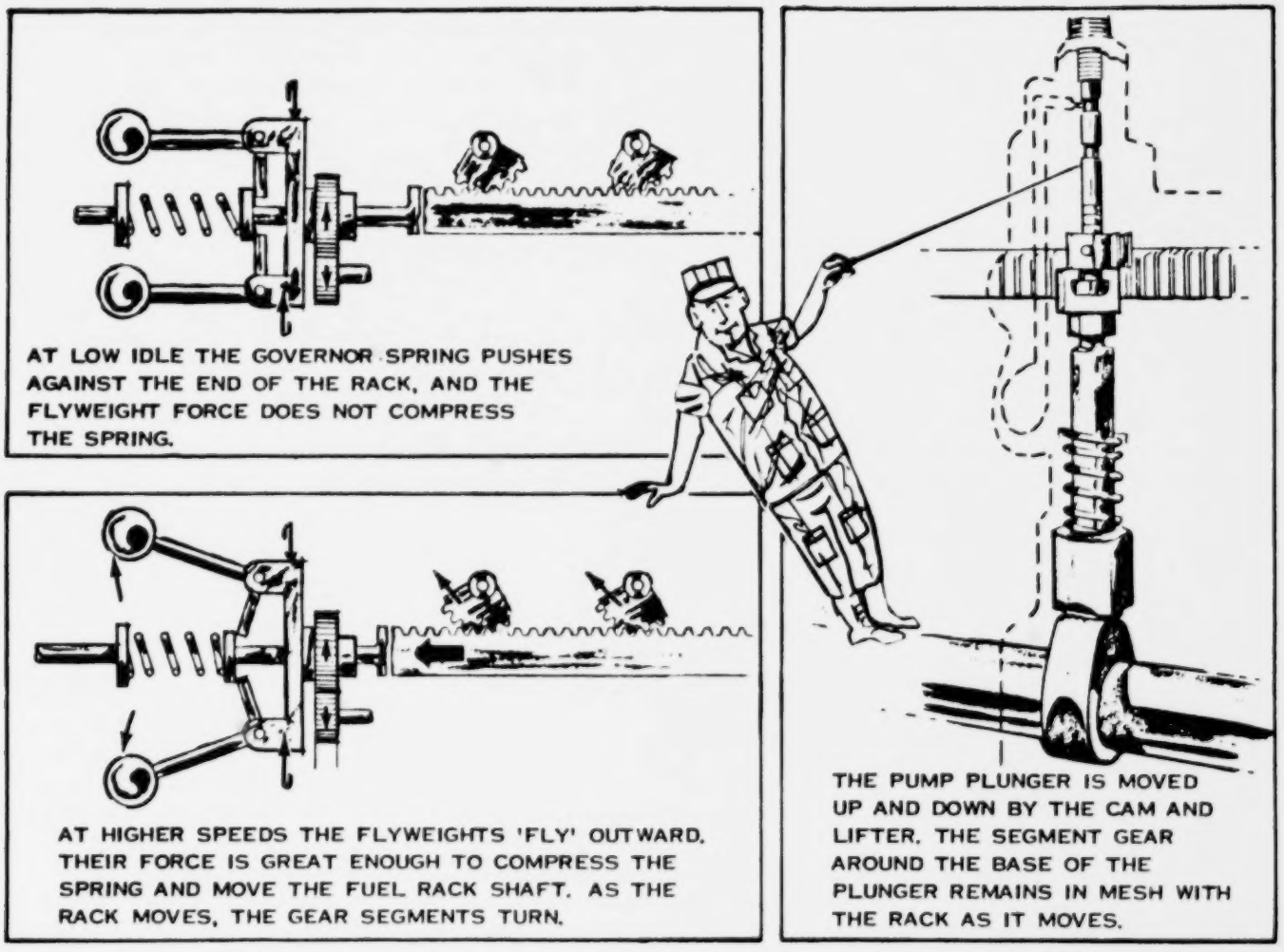
THE FUEL RACK HAS GEAR
TEETH ON ONE SIDE.

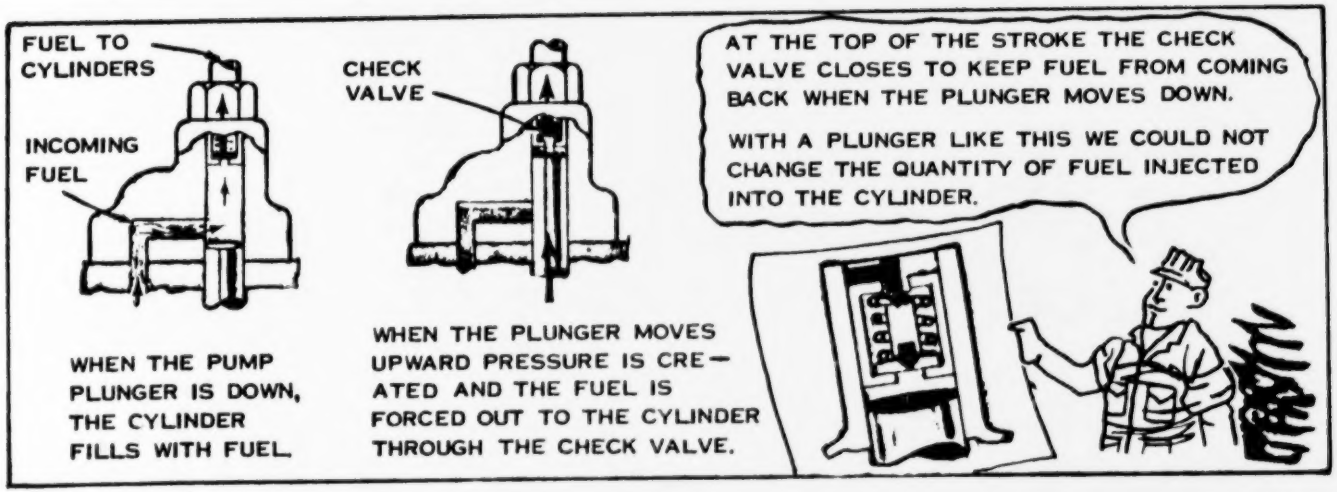


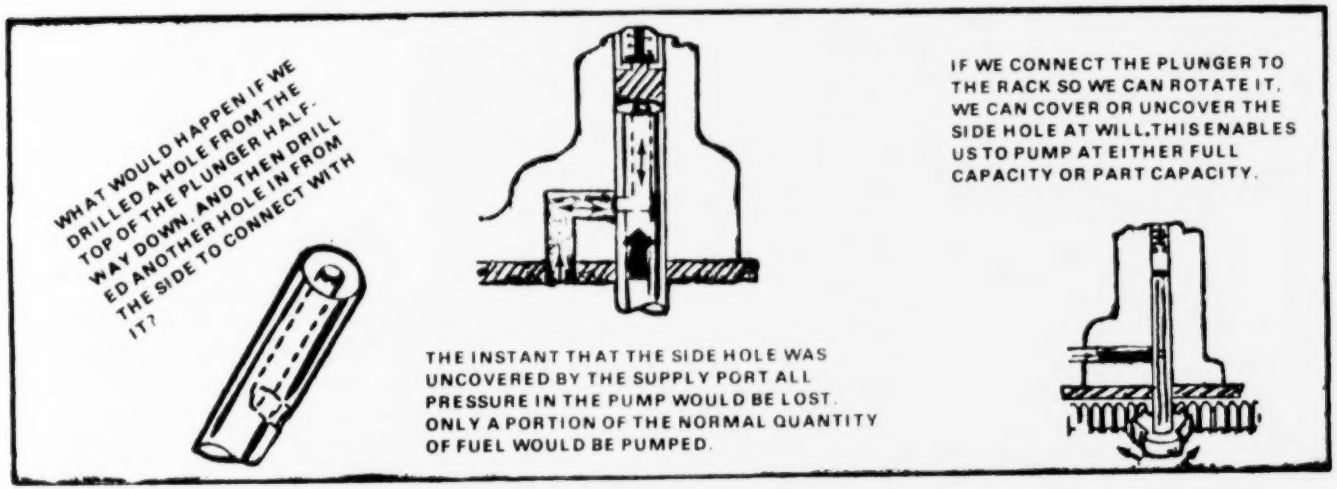
THESE TEETH MESH WITH
PARTIAL GEARS CALLED
GEAR SEGMENTS.

BEFORE WE PUT THE GOVERNOR TO WORK LET'S LOOK AT THE OPERATION OF THE FUEL INJECTION PUMP.

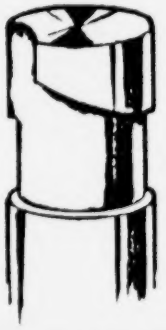
THE GEAR SEGMENT IS FASTENED TO THE BASE OF THE PUMP PLUNGER, AND MOVES UP AND DOWN WITH IT. THIS GEAR REMAINS ENGAGED WITH THE RACK.


AT LOW IDLE THE GOVERNOR SPRING PUSHES AGAINST THE END OF THE RACK, AND THE FLYWEIGHT FORCE DOES NOT COMPRESS THE SPRING.
AT HIGHER SPEEDS THE FLYWEIGHTS 'FLY' OUTWARD. THEIR FORCE IS GREAT ENOUGH TO COMPRESS THE SPRING AND MOVE THE FUEL RACK SHAFT. AS THE RACK MOVES, THE GEAR SEGMENTS TURN.
THE PUMP PLUNGER IS MOVED UP AND DOWN BY THE CAM AND LIFTER. THE SEGMENT GEAR AROUND THE BASE OF THE PLUNGER REMAINS IN MESH WITH THE RACK AS IT MOVES.

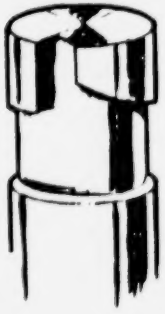

FUEL TO CYLINDERS
INCOMING FUEL
CHECK VALVE
WHEN THE PUMP PLUNGER IS DOWN, THE CYLINDER FILLS WITH FUEL.
WHEN THE PLUNGER MOVES UPWARD PRESSURE IS CREATED AND THE FUEL IS FORCED OUT TO THE CYLINDER THROUGH THE CHECK VALVE.
AT THE TOP OF THE STROKE THE CHECK VALVE CLOSES TO KEEP FUEL FROM COMING BACK WHEN THE PLUNGER MOVES DOWN.
WITH A PLUNGER LIKE THIS WE COULD NOT CHANGE THE QUANTITY OF FUEL INJECTED INTO THE CYLINDER.


WHAT WOULD HAPPEN IF WE DRILLED A HOLE FROM THE TOP OF THE PLUNGER HALF-WAY DOWN, AND THEN DRILLED ANOTHER HOLE IN FROM THE SIDE TO CONNECT WITH IT?
THE INSTANT THAT THE SIDE HOLE WAS UNCOVERED BY THE SUPPLY PORT ALL PRESSURE IN THE PUMP WOULD BE LOST. ONLY A PORTION OF THE NORMAL QUANTITY OF FUEL WOULD BE PUMPED.
IF WE CONNECT THE PLUNGER TO THE RACK SO WE CAN ROTATE IT, WE CAN COVER OR UNCOVER THE SIDE HOLE AT WILL. THIS ENABLES US TO PUMP AT EITHER FULL CAPACITY OR PART CAPACITY.

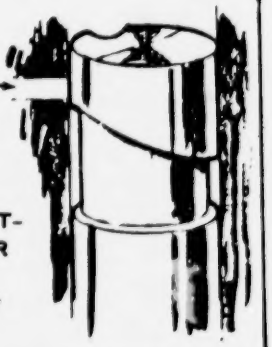
THE SYSTEM ACTUALLY USED TO CONTROL THE FUEL QUANTITY IS MUCH MORE INGENIOUS, INSTEAD OF A HOLE THE PLUNGER IS MADE WITH AN ODD GROOVE AROUND IT, CALLED A *HELIX* OR *SCROLL*



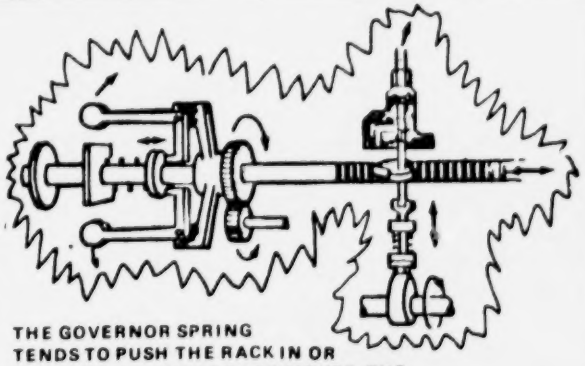
A SIMPLE SLOT TAKES THE PLACE OF THE VERTICAL HOLE WE USED BEFORE.



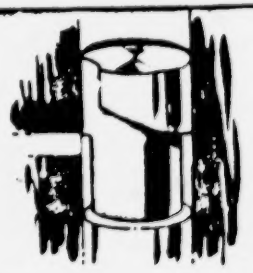
SUPPLY PORT



AS THE PLUNGER IS ROTATED BY THE RACK A HIGHER OR LOWER PART OF THE HELIX FACES THE SUPPLY PORT.



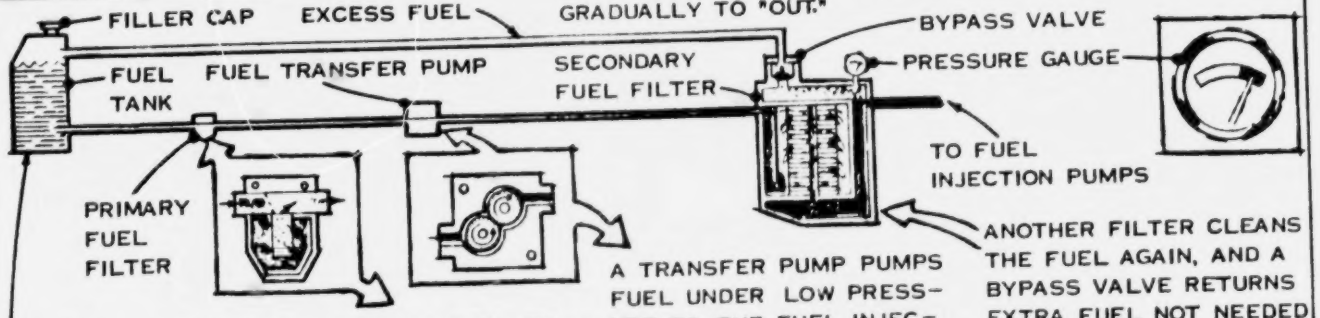
THE GOVERNOR SPRING TENDS TO PUSH THE RACK IN OR PULL IT OUT. AS THE RACK MOVES, THE QUANTITY OF FUEL PUMPED TO THE CYLINDERS CHANGES.



WHAT HAPPENS WHEN THE SLOT IS ALIGNED WITH THE SUPPLY PORT?
NO FUEL AT ALL IS PUMPED, AND THE ENGINE WILL STOP. THIS IS THE FUEL OFF POSITION.

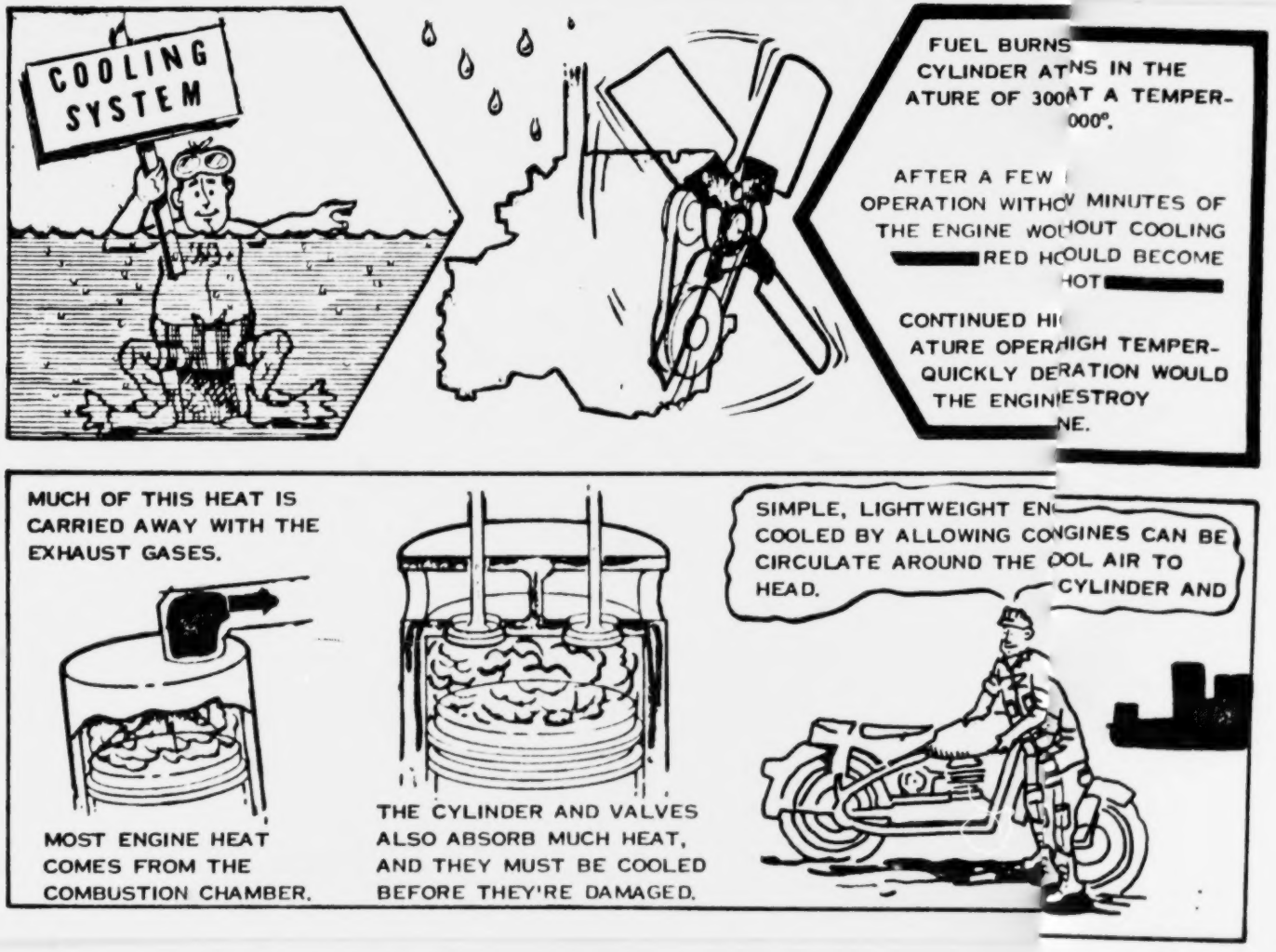
FUEL IS FURNISHED TO THE FUEL INJECTION PUMP BY A FUEL SYSTEM.

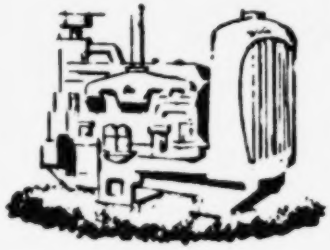
DIESEL VEHICLES OFTEN HAVE A DASHBOARD GAUGE TO INDICATE FUEL SYSTEM PRESSURE.
A DIRTY FUEL FILTER CAN CAUSE PRESSURE TO DROP GRADUALLY TO "OUT."


FILLER CAP
EXCESS FUEL
BYPASS VALVE
PRESSURE GAUGE
FUEL TANK
FUEL TRANSFER PUMP
SECONDARY FUEL FILTER
TO FUEL INJECTION PUMPS
PRIMARY FUEL FILTER
ANOTHER FILTER CLEANS THE FUEL AGAIN, AND A BYPASS VALVE RETURNS EXTRA FUEL NOT NEEDED TO THE TANK.
THE FUEL IS STORED IN A TANK.
A PRIMARY FUEL FILTER REMOVES DIRT.
A TRANSFER PUMP PUMPS FUEL UNDER LOW PRESSURE TO THE FUEL INJECTION PUMP.

1. DIESEL FUEL IS SUPPLIED TO THE CYLINDER BY A _____ _____ SYSTEM.
2. THE 2 SPEEDS OF A DIESEL ENGINE ARE CALLED _____ AND _____.
3. A CHANGE IN ENGINE SPEED IS "SENSED" BY THE _____.
4. SPEED IS CONTROLLED BY VARYING THE AMOUNT OF _____ SUPPLIED TO THE ENGINE.
5. THE PUMP PLUNGER GEAR SEGMENT IS ROTATED BY THE BACK AND FORTH MOTION OF THE _____ _____.
6. THE CURVED RECESS ON THE PLUNGER THAT METERS THE FUEL IS CALLED A _____.

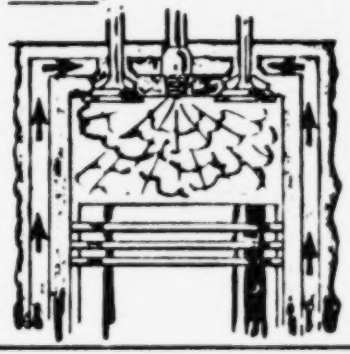
ANSWERS: 1. FUEL INJECTION 2. LOW IDLE, HIGH IDLE (RUN) 3. GOVERNOR
4. FUEL (DIESEL OIL) 5. FUEL RACK 6. HELIX (SCROLL)

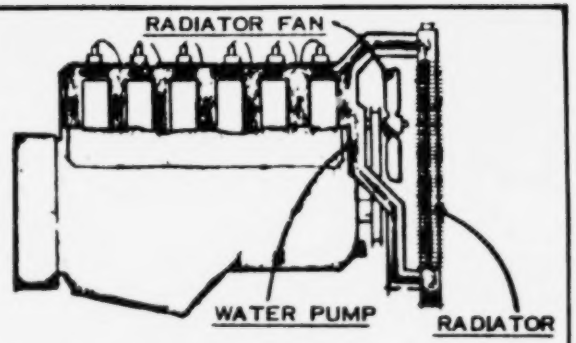

COOLING SYSTEM
FUEL BURNS
CYLINDER AT
ATURE OF 300
NS IN THE
T A TEMPER-
000°.
AFTER A FEW
OPERATION WITHO
V MINUTES OF
THE ENGINE WO
OUT COOLING
RED HO
OULD BECOME
HOT
CONTINUED HI
ATURE OPER
HIGH TEMPER-
QUICKLY DE
RATION WOULD
THE ENGIN
ESTROY
NE.
MUCH OF THIS HEAT IS CARRIED AWAY WITH THE EXHAUST GASES.
MOST ENGINE HEAT COMES FROM THE COMBUSTION CHAMBER.
THE CYLINDER AND VALVES ALSO ABSORB MUCH HEAT, AND THEY MUST BE COOLED BEFORE THEY'RE DAMAGED.
SIMPLE, LIGHTWEIGHT EN
COOLED BY ALLOWING
CIRCULATE AROUND THE
HEAD.
ENGINES CAN BE
OOL AIR TO
CYLINDER AND



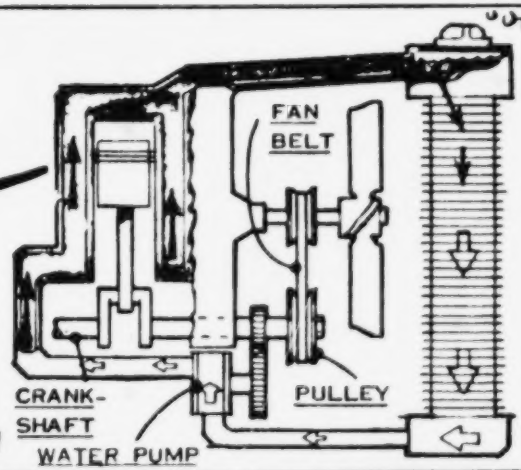
THERE'S LOTS MORE HEAT IN A DIESEL ENGINE, WHICH IS WATER-COOLED.

THE UPPER PART OF EVERY CYLINDER HAS SPACE FOR WATER, CALLED A WATER JACKET.





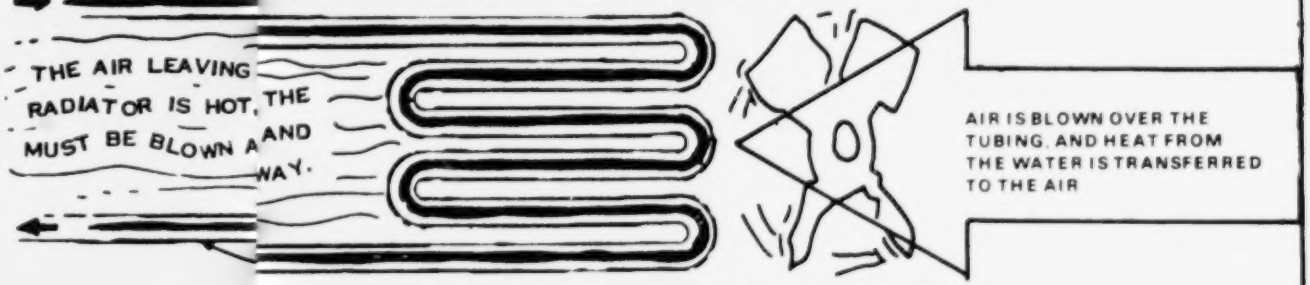
THE WATER IN THE WATER JACKET WOULD SOON BOIL IF IT WASN'T COOLED TOO, SO A WATER PUMP SENDS IT TO A RADIATOR FOR COOLING.



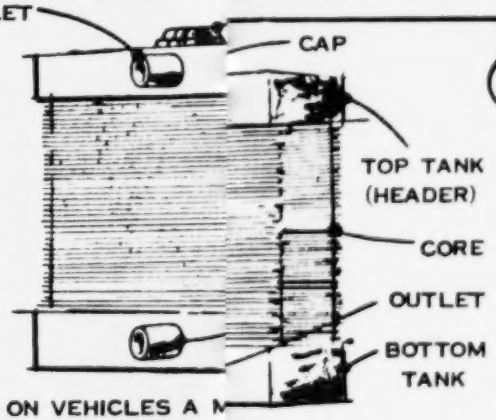
THE FAN IS BELT-DRIVEN BY THE CRANK-SHAFT.
ON MANY DIESEL ENGINES THE WATER PUMP IS DRIVEN BY A TIMING GEAR.

THE WATER IS
HERE'S A SIMP
TUBING IS BEN
AND HOT WATE

OOLED BY A RADIATOR THAT RADIATES OR TRANSFERS HEAT TO THE AIR.
E RADIATOR, CONSISTING OF A LENGTH OF HOLLOW METAL TUBING. THE
BACK AND FORTH TO EXPOSE MORE RADIATING SURFACE TO THE AIR,
FROM THE ENGINE IS PUMPED THROUGH IT.


THE AIR LEAVING
RADIATOR IS HOT,
MUST BE BLOWN A
THE
AND
WAY.
AIR IS BLOWN OVER THE TUBING, AND HEAT FROM THE WATER IS TRANSFERRED TO THE AIR

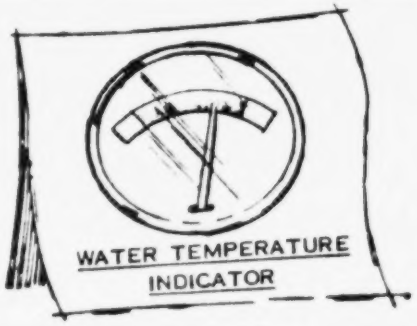
THE WATER RETURNING TO THE ENGINE TO RE-COOL THE CYLINDERS IS NOW LOWER IN TEMPERATURE.



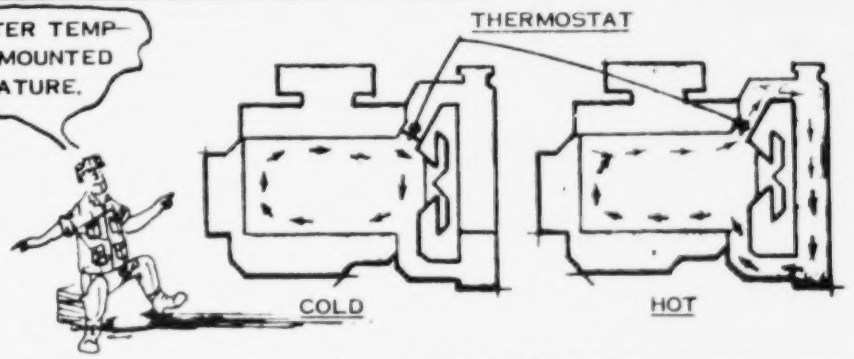
ON VEHICLES A M
EFFICIENT RADIA
UCH MORE
OR IS USED.

FLAT METAL "FINS" ARE FORCED OVER THE TUBES DURING MANUFACTURE. HEAT FROM THE TUBES FLOWS INTO THE FINS, INCREASING THE RADIATOR SURFACE.

THE RADIATOR KEEPS ENGINE WATER TEMPERATURE NORMAL. A DASHBOARD-MOUNTED GAUGE INDICATES WATER TEMPERATURE.

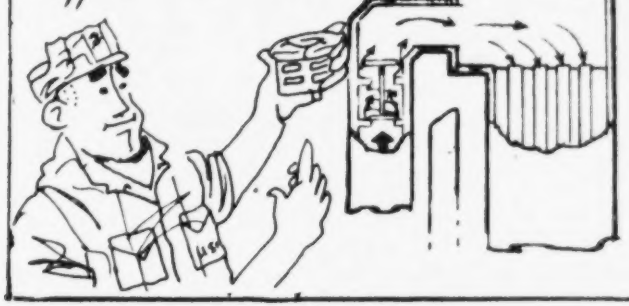


WATER TEMPERATURE INDICATOR



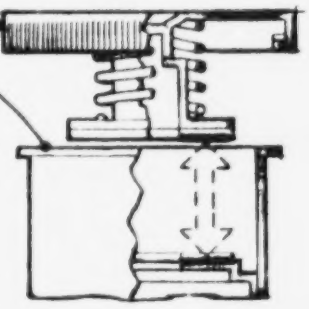
WHEN THE ENGINE WATER IS COLD THE RADIATOR IS NOT NEEDED SO IT IS CLOSED OFF BY AN AUTOMATIC HEAT-OPERATED VALVE CALLED A WATER TEMPERATURE REGULATOR, OR THERMOSTAT.

THE WATER TEMPERATURE REGULATOR NORMALLY BEGINS TO OPEN WHEN WATER IN THE ENGINE REACHES 160°.



THE CAP ON THE RADIATOR IS CALLED A PRESSURE REGULATING CAP

WATER CAN BE ADDED TO THE COOLING SYSTEM THROUGH THE FILLER NECK.

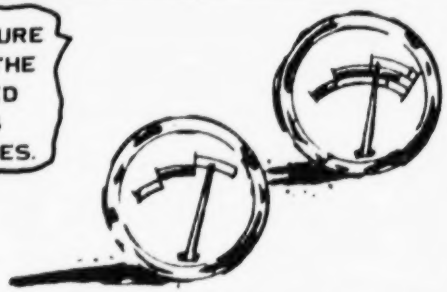


THE IMPORTANT PARTS OF THE CAP ARE THE SEAL AND THE SPRING.

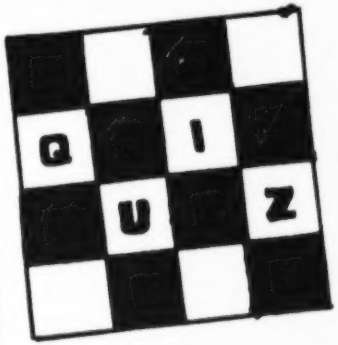
THE SPRING KEEPS THE COOLING SYSTEM SEALED UNTIL THE PRESSURE OVERCOMES THE SPRING FORCE.

THE BOILING POINT CAN BE RAISED FROM 212° TO 240° OR HIGHER.

WHEN THE PRESSURE RISES TOO HIGH THE SEAL IS UNSEATED AND THE EXCESS PRESSURE ESCAPES.



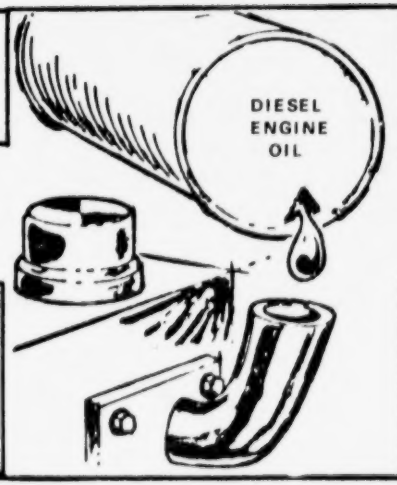
SOME DIESEL VEHICLES HAVE A WATER PRESSURE GAUGE, IN addition TO THE WATER TEMPERATURE INDICATOR. SIMILAR COLORED BANDS ARE READ ON BOTH GAUGES.



1. AN ENGINE CAN BE EITHER AIR COOLED OR _____ COOLED.
2. THE BOILING POINT OF WATER CAN BE RAISED IF THE COOLING SYSTEM IS _____.
3. A RADIATOR TRANSFERS HEAT FROM WATER TO _____.
4. IN COLD WEATHER AN ENGINE WILL HEAT TO NORMAL OPERATING TEMPERATURE MORE QUICKLY BECAUSE OF THE _____.
5. AIR IS FORCED THROUGH A RADIATOR BY A _____.

ANSWERS: 1. WATER 2. PRESSURIZED (SEALED, CLOSED) 3. AIR 4. THERMOSTAT 5. FAN

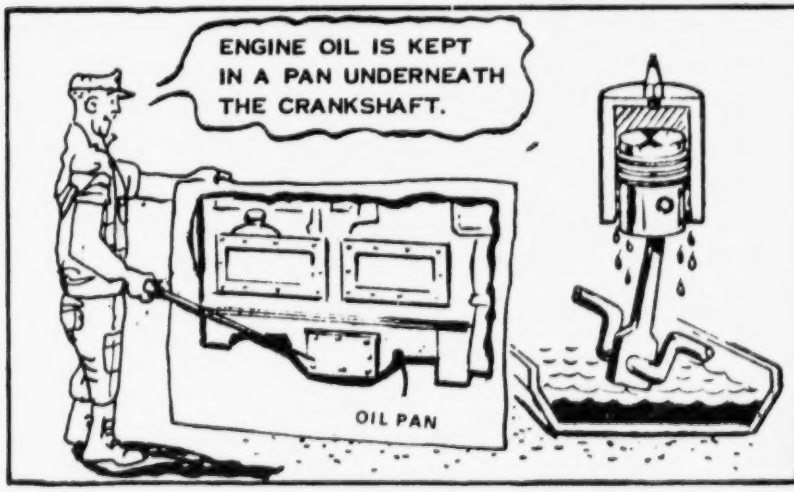
LUBRICATING SYSTEM



EVERYONE KNOWS THAT YOU HAVE TO PUT OIL IN AN ENGINE.

CAN YOU LIST SEVERAL REASONS WHY AN ENGINE USES OIL?

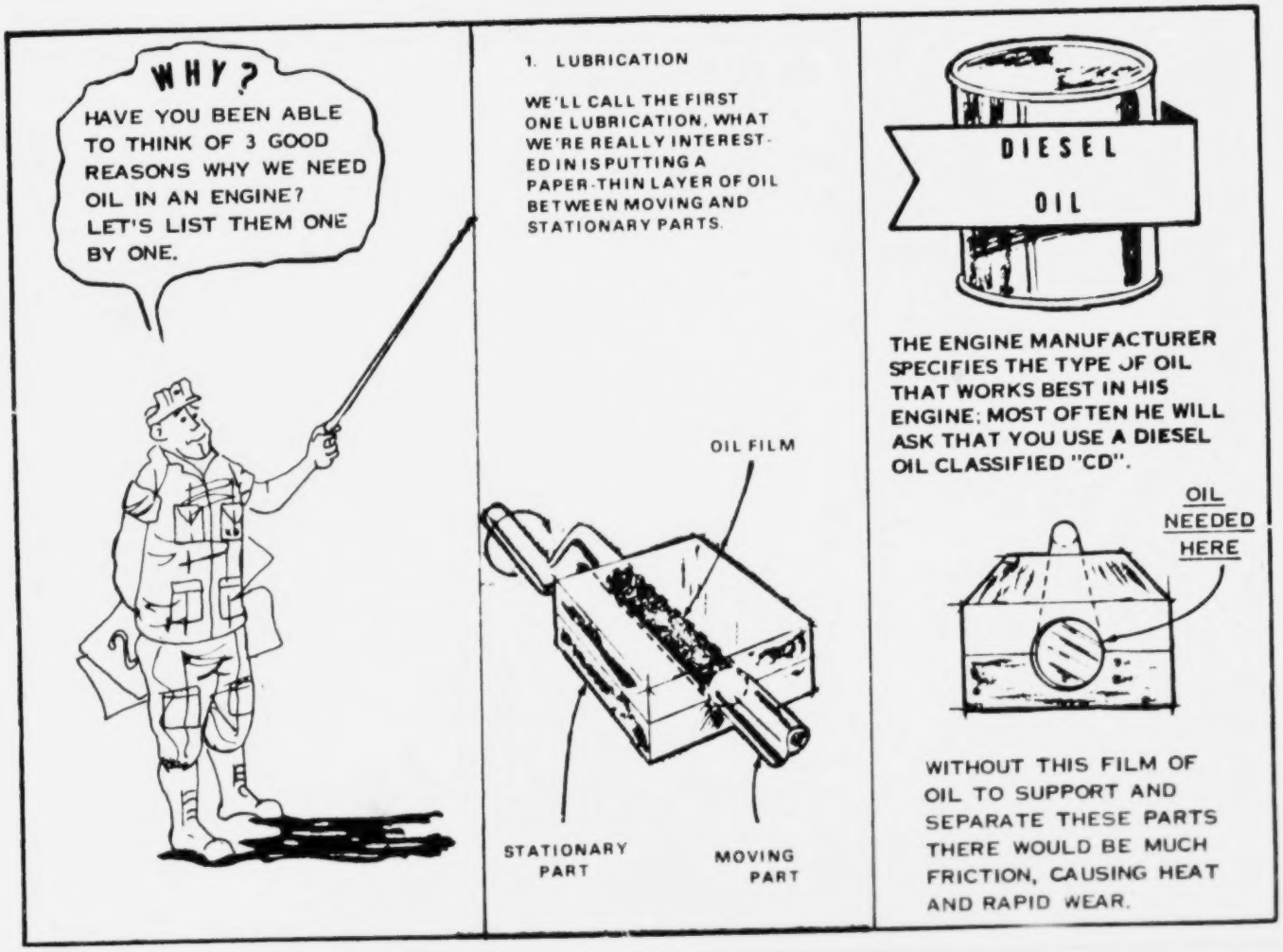
MODERN ENGINES REQUIRE SPECIAL OIL, AND THE OIL THAT IS PUT INTO A DIESEL ENGINE IS AN ENTIRELY DIFFERENT KIND OF OIL



IN EVERY ENGINE THERE IS CRANK-CASE OIL DILUTION BECAUSE SOME FUEL AND EXHAUST GASES WILL LEAK PAST THE PISTONS DOWN INTO THE OIL.

DIESEL FUEL CONTAINS SULPHUR, AND THE BURNED GASES CONTAIN SULPHURIC ACID.

A SPECIAL DIESEL OIL THAT CONTAINS ANTI-ACID ADDITIVES MUST BE USED TO PREVENT ENGINE CORROSION.

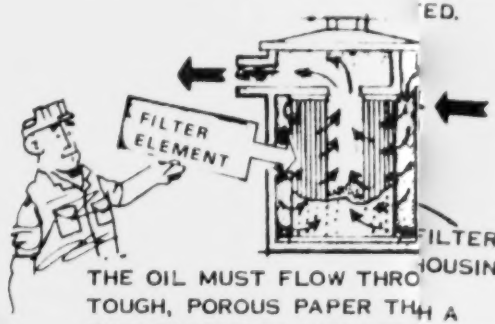

WHY?
HAVE YOU BEEN ABLE TO THINK OF 3 GOOD REASONS WHY WE NEED OIL IN AN ENGINE? LET'S LIST THEM ONE BY ONE.
1. LUBRICATION
WE'LL CALL THE FIRST ONE LUBRICATION, WHAT WE'RE REALLY INTERESTED IN IS PUTTING A PAPER-THIN LAYER OF OIL BETWEEN MOVING AND STATIONARY PARTS.
OIL FILM
STATIONARY PART
MOVING PART
DIESEL
OIL
THE ENGINE MANUFACTURER SPECIFIES THE TYPE OF OIL THAT WORKS BEST IN HIS ENGINE; MOST OFTEN HE WILL ASK THAT YOU USE A DIESEL OIL CLASSIFIED "CD".
OIL NEEDED HERE
WITHOUT THIS FILM OF OIL TO SUPPORT AND SEPARATE THESE PARTS THERE WOULD BE MUCH FRICTION, CAUSING HEAT AND RAPID WEAR.

2 CLEANING

THE SECOND FUNCTION OF OIL IS TO CLEAN. A CONSTANT FLOW OF OIL OVER MOVING PARTS WILL CARRY AWAY METAL PARTICLES THAT ARE WORN OR BROKEN OFF.

THE OIL FILM ON CYLINDER WALLS DRIPS BACK DOWN INTO THE SUMP, CARRYING WITH IT SLUDGE AND LACQUER DEPOSITS.

AN OIL FILTER REMOVES DI
FORE THE OIL IS RECIRCUL BE-
ED.



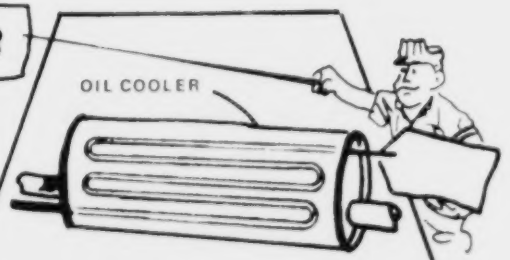
FILTER
OUSING
H A
TRAPS
LEAN

THE OIL MUST FLOW THRO
TOUGH, POROUS PAPER TH
FINE PARTICLES BUT LETS
OIL PASS THROUGH.

COOLING 3

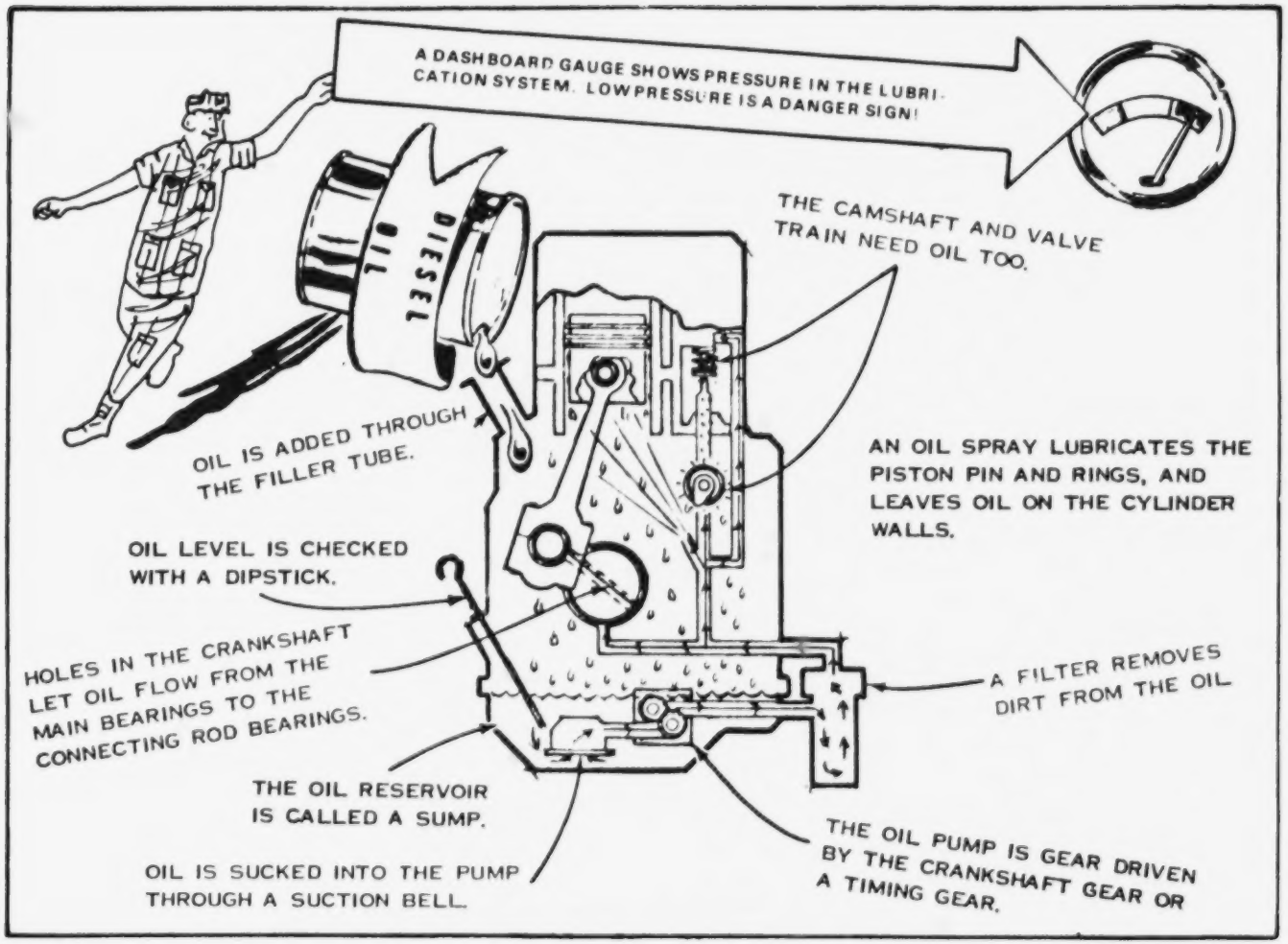
THE THIRD FUNCTION OF OIL IS TO COOL. FRICTION CAN BE REDUCED BY LUBRICATION BUT NOT ELIMINATED.

AS THE OIL PASSES OVER MOVING PARTS IT ABSORBS HEAT FROM THEM.



IN SOME DIESEL ENGINES THE OIL IS COOLED BEFORE IT IS RECIRCULATED. COOL WATER FROM THE RADIATOR IS PUMPED THROUGH TUBES IN THE OIL COOLER BEFORE IT IS SENT TO THE BLOCK TO COOL THE ENGINE. OIL IS PUMPED THROUGH THE OIL COOLER HOUSING.

IF WE LOOKED
OF AN ACTUA TO THE END
WE MIGHT SEE L COOLER
LIKE THIS. ANY TUBES,
COOLED OIL C
MOVING PARTS AGAIN COOL
*BREAK DOWN D WON'T
TEMPERATURE OM HIGH


A DASHBOARD GAUGE SHOWS PRESSURE IN THE LUBRICATION SYSTEM. LOW PRESSURE IS A DANGER SIGN!
OIL
DIESEL
THE CAMSHAFT AND VALVE TRAIN NEED OIL TOO.
OIL IS ADDED THROUGH THE FILLER TUBE.
AN OIL SPRAY LUBRICATES THE PISTON PIN AND RINGS, AND LEAVES OIL ON THE CYLINDER WALLS.
OIL LEVEL IS CHECKED WITH A DIPSTICK.
HOLES IN THE CRANKSHAFT LET OIL FLOW FROM THE MAIN BEARINGS TO THE CONNECTING ROD BEARINGS.
A FILTER REMOVES DIRT FROM THE OIL.
THE OIL RESERVOIR IS CALLED A SUMP.
THE OIL PUMP IS GEAR DRIVEN BY THE CRANKSHAFT GEAR OR A TIMING GEAR.
OIL IS SUCKED INTO THE PUMP THROUGH A SUCTION BELL.

1. THE 3 F
2. A GOOD-
ENGINE
3. TO KEEF
4. TO KEEF
5. IF WE LO
WE SEE
OIL PRES
PUMP IS

UNCTIONS OF ENGINE OIL ARE TO _____, _____, AND _____.

QUALITY AUTOMOBILE OIL CAN BE USED REGULARLY IN A DIESEL (TRUE OR FALSE). _____.

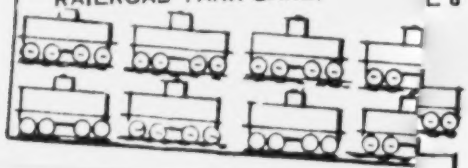
OIL CLEAN, WE USE AN _____ IN THE ENGINE.

OIL COOL AN _____ MAY BE ADDED.

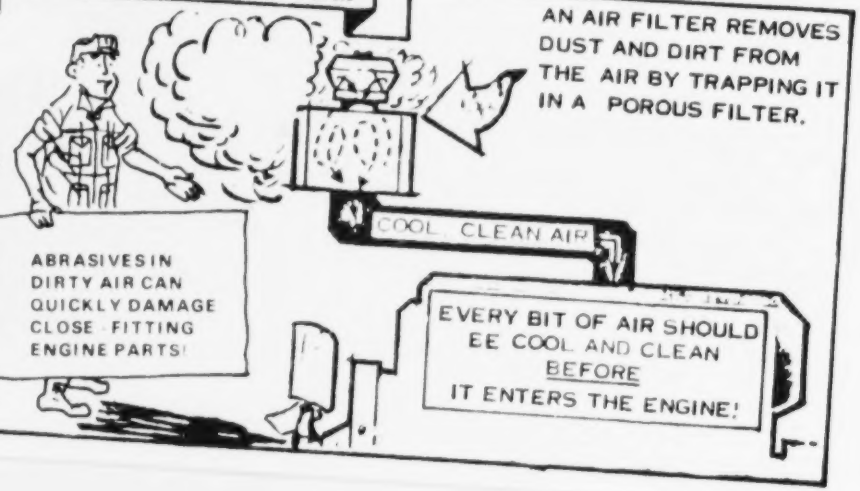
OOK AT THE "ENGINE OIL PRESSURE GAUGE" AT THE RIGHT. THAT THE CENTER PART OF THE SCALE IS MARKED "LOW IDLE." SSURE IS LOWER AT LOW ENGINE SPEEDS BECAUSE THE OIL DRIVEN BY THE _____.

ANSWERS: 1. COOL, CLEAN, LUBRICATE 2. FALSE 3. OIL FILT
4. OIL COOLER 5. TIMING GEARS

THE LAST SYSTEM THAT WE'LL DISCUSS IS PERHAPS THE MOST IMPORTANT.
THIS IS THE AIR INTAKE, OR AIR INDUCTION SYSTEM.
AN ENGINE NEEDS TREMENDOUS QUANTITIES OF AIR WHEN OPER
A SIMPLE 4-CYLINDER ENGINE ATING.
ENOUGH AIR IN AN HOUR TO FIL USES
RAILROAD TANK CARS! L 8

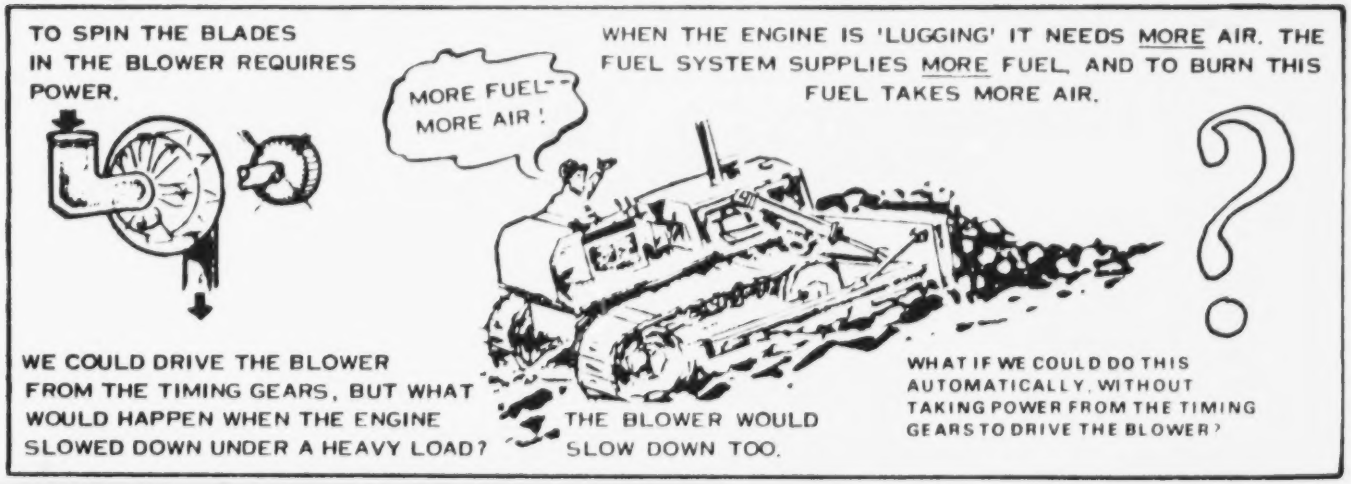


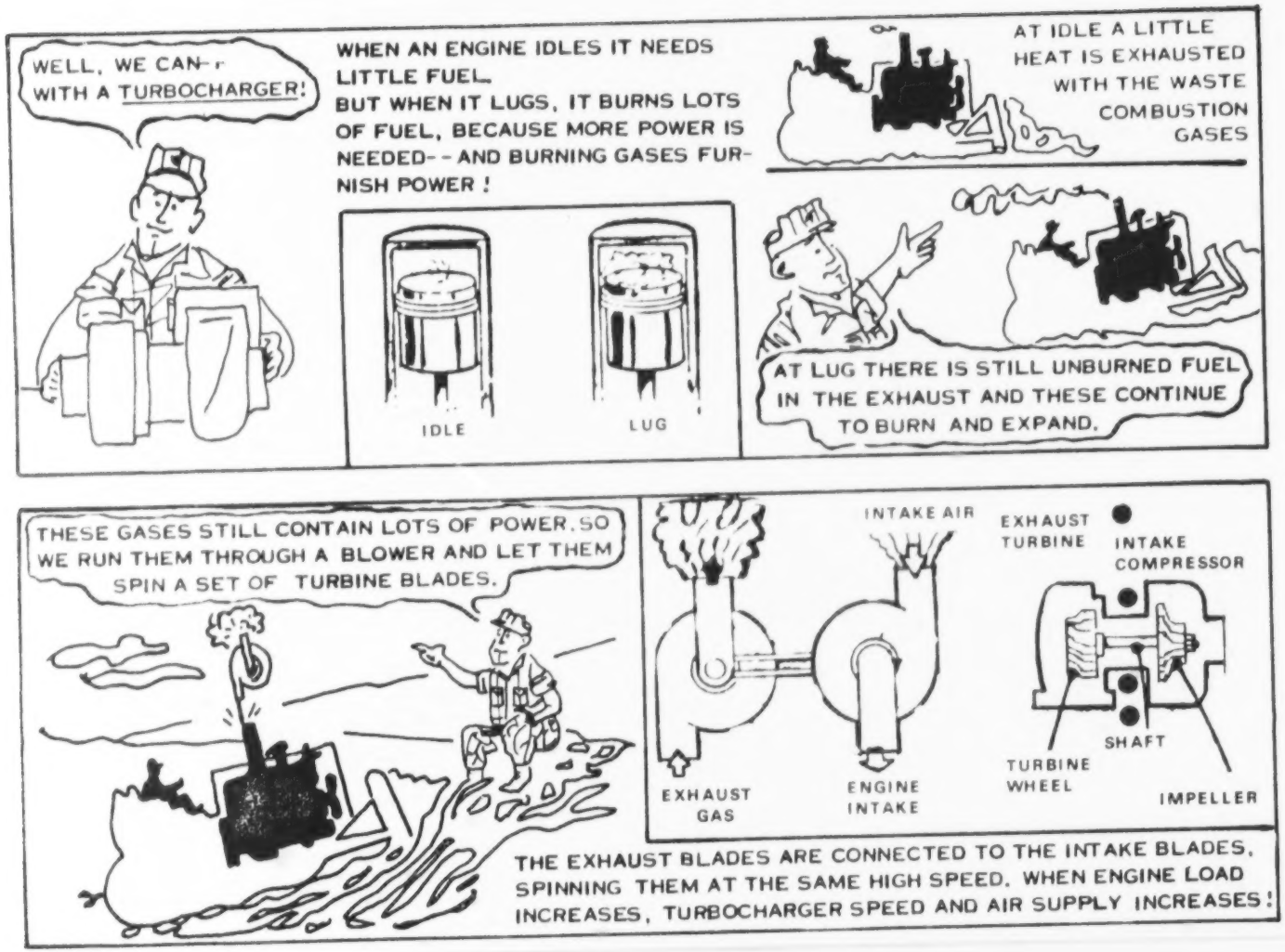
AIR INDUCTION SYSTEM

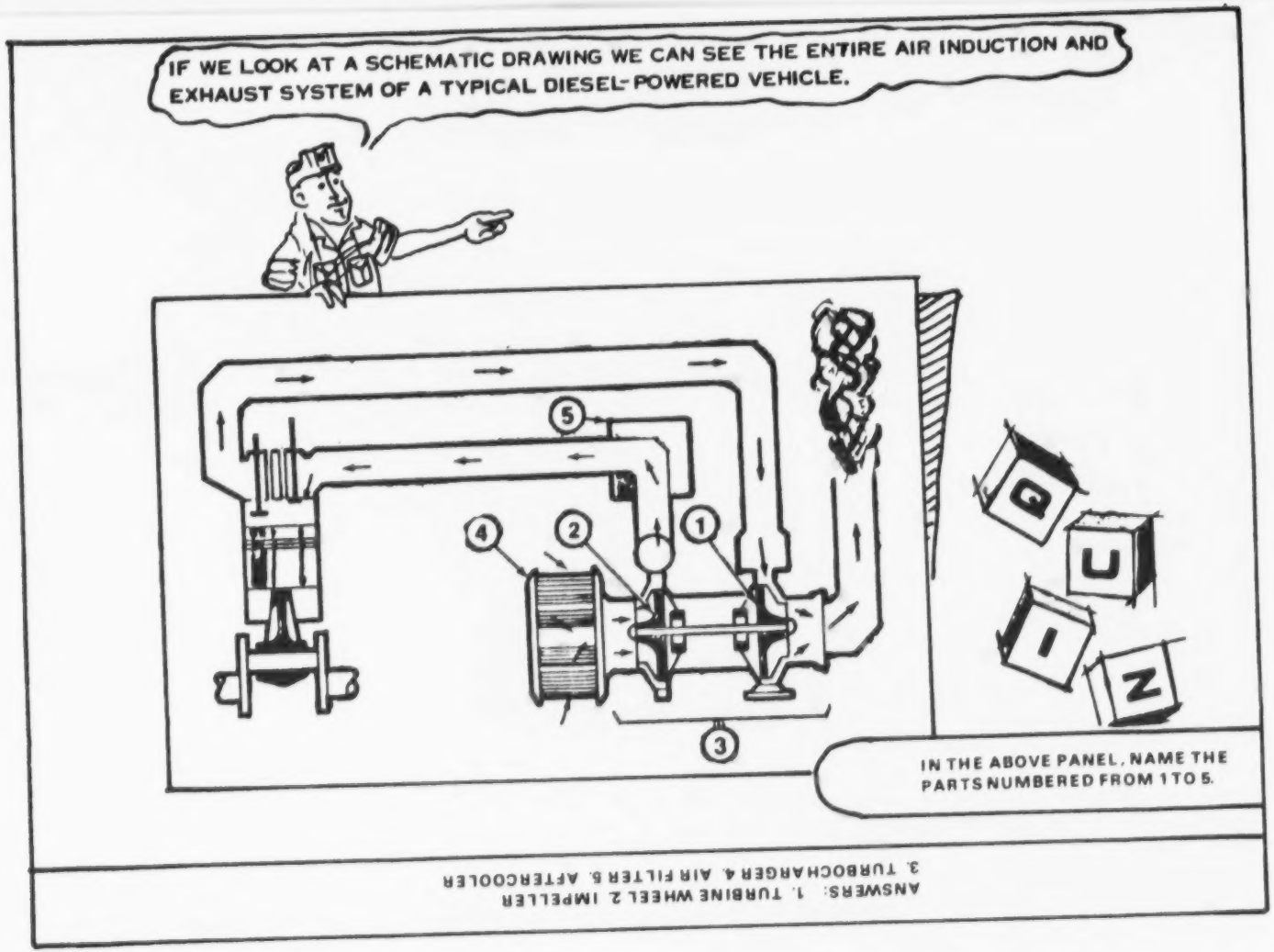

COOL CLEAN AIR
ABRASIVES IN DIRTY AIR CAN QUICKLY DAMAGE CLOSE-FITTING ENGINE PARTS!
EVERY BIT OF AIR SHOULD BE COOL AND CLEAN BEFORE IT ENTERS THE ENGINE!

AN AIR FILTER REMOVES DUST AND DIRT FROM THE AIR BY TRAPPING IT IN A POROUS FILTER.

WITH SIMPLE ENGINES THE AIR IS "SUCKED" INTO THE COMBUSTION CHAMBER ON THE INTAKE STROKE.
WE CAN GET MORE AIR INTO THE CYLINDER AND MAKE COMBUSTION MORE EFFICIENT IF WE BLOW THE AIR INTO THE CYLINDER.
WE CAN ALSO GET MORE AIR INTO THE CYLINDER IF WE COOL IT. BY COOLING IT WE "SHRINK" IT, SO MORE AIR CAN BE PACKED INTO THE SAME SPACE.
RADIATOR WATER
AFTERCOOLER
AFTER LEAVING THE BLOWER THE AIR IS HOT. IT CAN BE COOLED IN AN AFTERCOOLER USING RADIATOR WATER OR OUTSIDE AIR.


TO SPIN THE BLADES IN THE BLOWER REQUIRES POWER.
WHEN THE ENGINE IS 'LUGGING' IT NEEDS MORE AIR. THE FUEL SYSTEM SUPPLIES MORE FUEL, AND TO BURN THIS FUEL TAKES MORE AIR.
MORE FUEL-- MORE AIR!
WE COULD DRIVE THE BLOWER FROM THE TIMING GEARS, BUT WHAT WOULD HAPPEN WHEN THE ENGINE SLOWED DOWN UNDER A HEAVY LOAD?
THE BLOWER WOULD SLOW DOWN TOO.
WHAT IF WE COULD DO THIS AUTOMATICALLY, WITHOUT TAKING POWER FROM THE TIMING GEARS TO DRIVE THE BLOWER?


WELL, WE CAN-r WITH A TURBOCHARGER!
WHEN AN ENGINE IDLES IT NEEDS LITTLE FUEL.
BUT WHEN IT LUGS, IT BURNS LOTS OF FUEL, BECAUSE MORE POWER IS NEEDED--AND BURNING GASES FURNISH POWER!
AT IDLE A LITTLE HEAT IS EXHAUSTED WITH THE WASTE COMBUSTION GASES
IDLE
LUG
AT LUG THERE IS STILL UNBURNED FUEL IN THE EXHAUST AND THESE CONTINUE TO BURN AND EXPAND.
THESE GASES STILL CONTAIN LOTS OF POWER. SO WE RUN THEM THROUGH A BLOWER AND LET THEM SPIN A SET OF TURBINE BLADES.
INTAKE AIR
EXHAUST TURBINE
INTAKE COMPRESSOR
SHAFT
TURBINE WHEEL
IMPELLER
EXHAUST GAS
ENGINE INTAKE
THE EXHAUST BLADES ARE CONNECTED TO THE INTAKE BLADES, SPINNING THEM AT THE SAME HIGH SPEED. WHEN ENGINE LOAD INCREASES, TURBOCHARGER SPEED AND AIR SUPPLY INCREASES!


IF WE LOOK AT A SCHEMATIC DRAWING WE CAN SEE THE ENTIRE AIR INDUCTION AND EXHAUST SYSTEM OF A TYPICAL DIESEL-POWERED VEHICLE.
5
4
2
1
3
Q
U
I
N
IN THE ABOVE PANEL, NAME THE PARTS NUMBERED FROM 1 TO 5.
ANSWERS: 1. TURBINE WHEEL 2. IMPELLER
3. TURBOCHARGER 4. AIR FILTER 5. AFTERCOOLER

WE HOPE THAT THIS BOOKLET HAS HELPED YOU LEARN A FEW BASIC FACTS ABOUT ENGINES, AND TAUGHT YOU THE DIFFERENCE BETWEEN GASOLINE AND DIESEL ENGINES.
THERE ARE SOME ASPECTS THAT WE HAVEN'T COVERED, SUCH AS ELECTRICAL SYSTEMS. THESE ARE LIKE AUTOMOBILE SYSTEMS, BUT ARE EVEN SIMPLER.
THERE ARE OTHER VALVES, FILTERS AND ATTACHMENTS THAT ARE FITTED TO VARIOUS MODELS AND DESIGNS OF DIESEL ENGINES. WE CAN'T BEGIN TO SHOW THEM ALL, SO WE'LL CONCLUDE WITH THIS.
00005
THIS IS CALLED A SERVICE METER AND IT RECORDS THE APPROXIMATE LENGTH OF TIME AN ENGINE RUNS. THIS METER IS CONNECTED TO THE TIMING GEARS, AND HELPS DETERMINE WHEN LUBRICATION AND MAINTENANCE ARE REQUIRED.
THE END